



**Barcelona  
Supercomputing  
Center**

*Centro Nacional de Supercomputación*



# Modeling the dust cycle at BSC

## From R&D to operational forecast

Sara Basart ([sara.basart@bsc.es](mailto:sara.basart@bsc.es))

C. Pérez García-Pando, O. Jorba, E. Di Tomaso, L. Vendrell, E.  
Terradellas, G. García-Castrillo, F. Benincasa and K. Serradell



## What

Environmental modelling and forecasting

## Why

Our strength ...

- ... research ...
- ... operations ...
- ... services ...
- ... high resolution ...



***MareNostrum  
supercomputer***

## How

Develop a capability to model air quality processes from urban to global and the impacts on weather, health and ecosystems

Implement climate prediction system for subseasonal-to-decadal climate prediction

Develop user-oriented services that favour both technology transfer and adaptation

Use cutting-edge HPC and Big Data technologies for the efficiency and user-friendliness of Earth system models

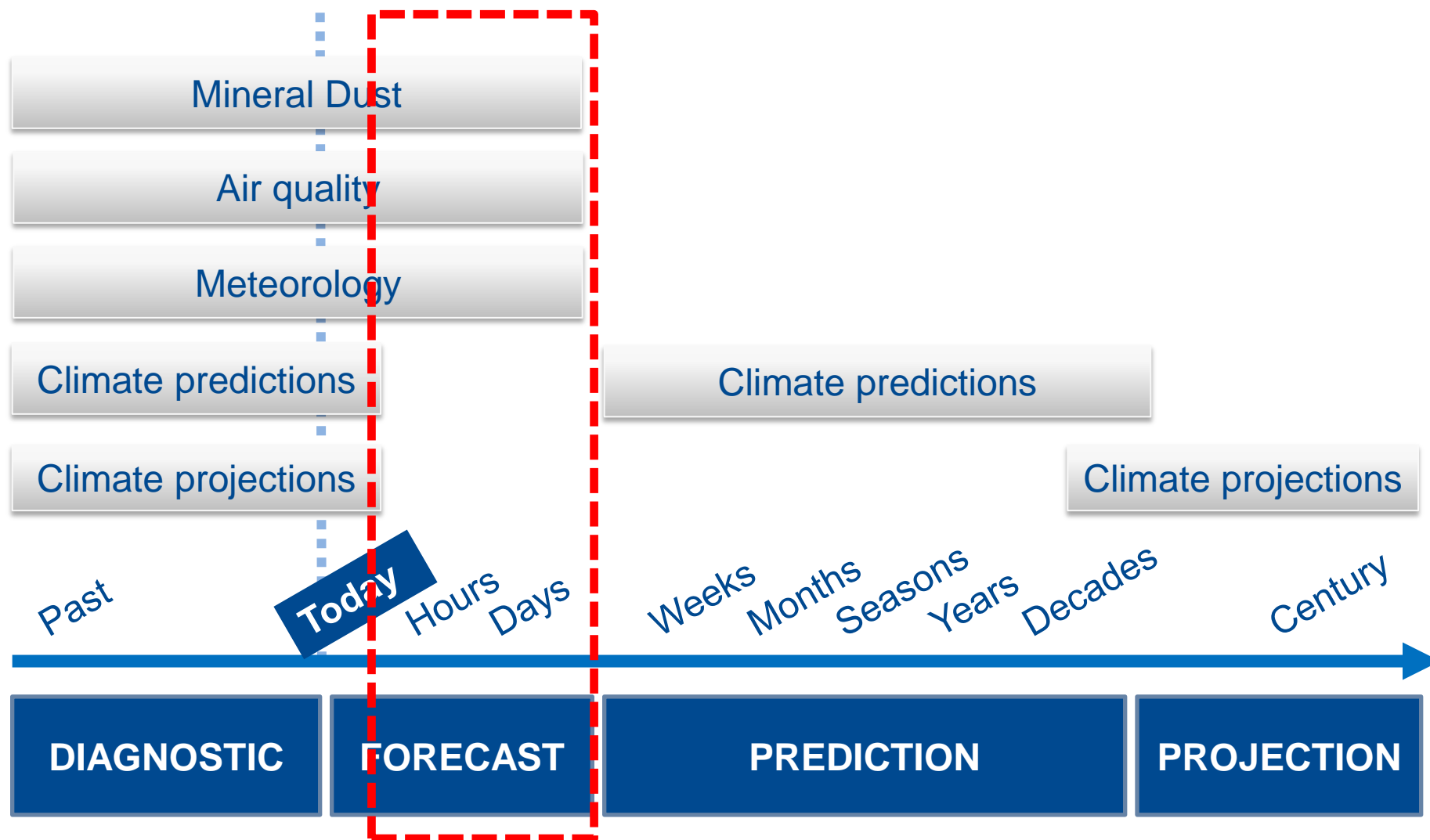
Earth system  
services

Climate  
prediction

Atmospheric  
composition

Computational  
Earth sciences

## Short-term forecast



## CALIOPE

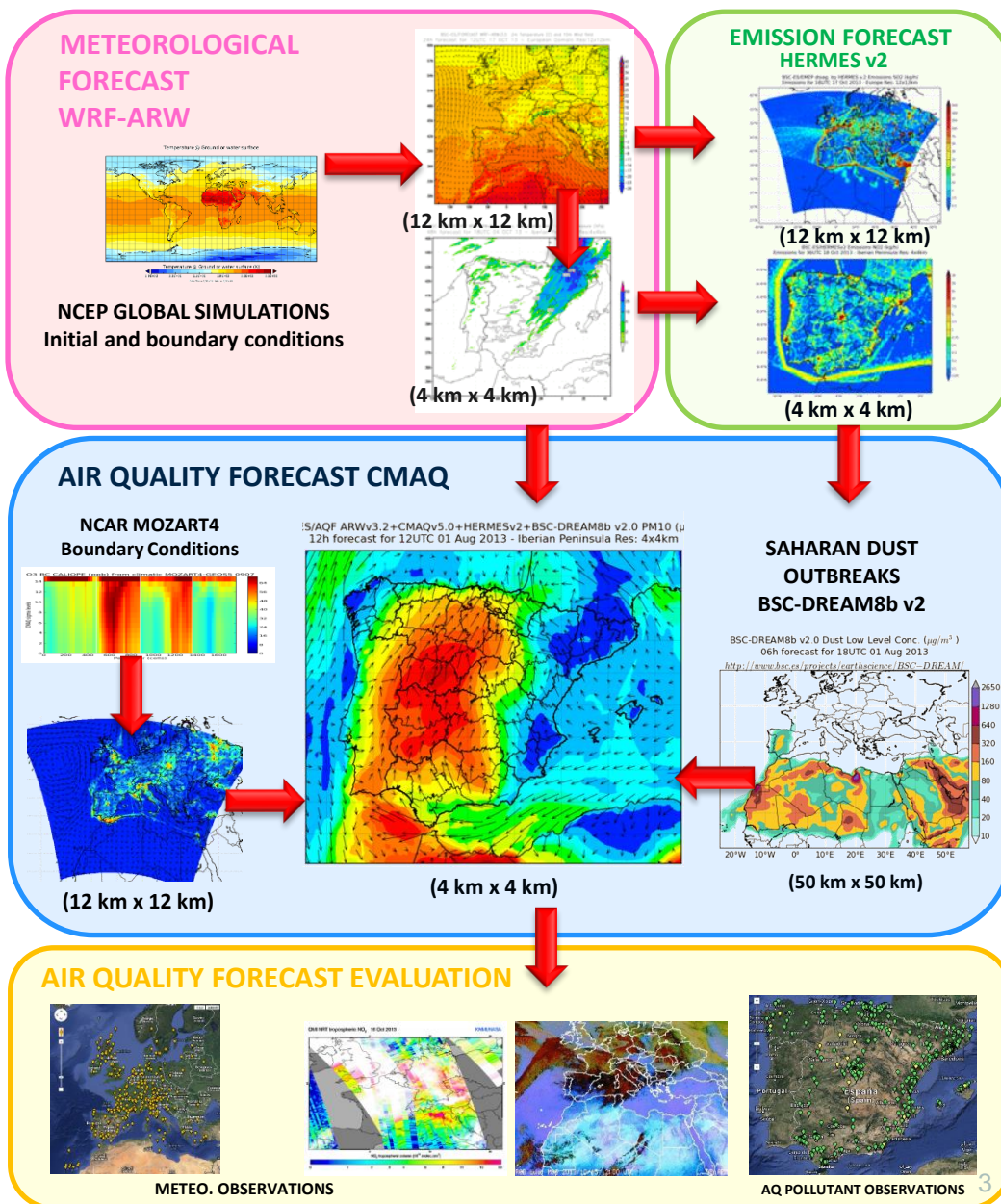
([www.bsc.es/caliope](http://www.bsc.es/caliope))

- Quantify relation between emissions, meteorology and air concentration
- Forecast air pollution episodes
- Provide and develop short and long term mitigation plans

## Domains:

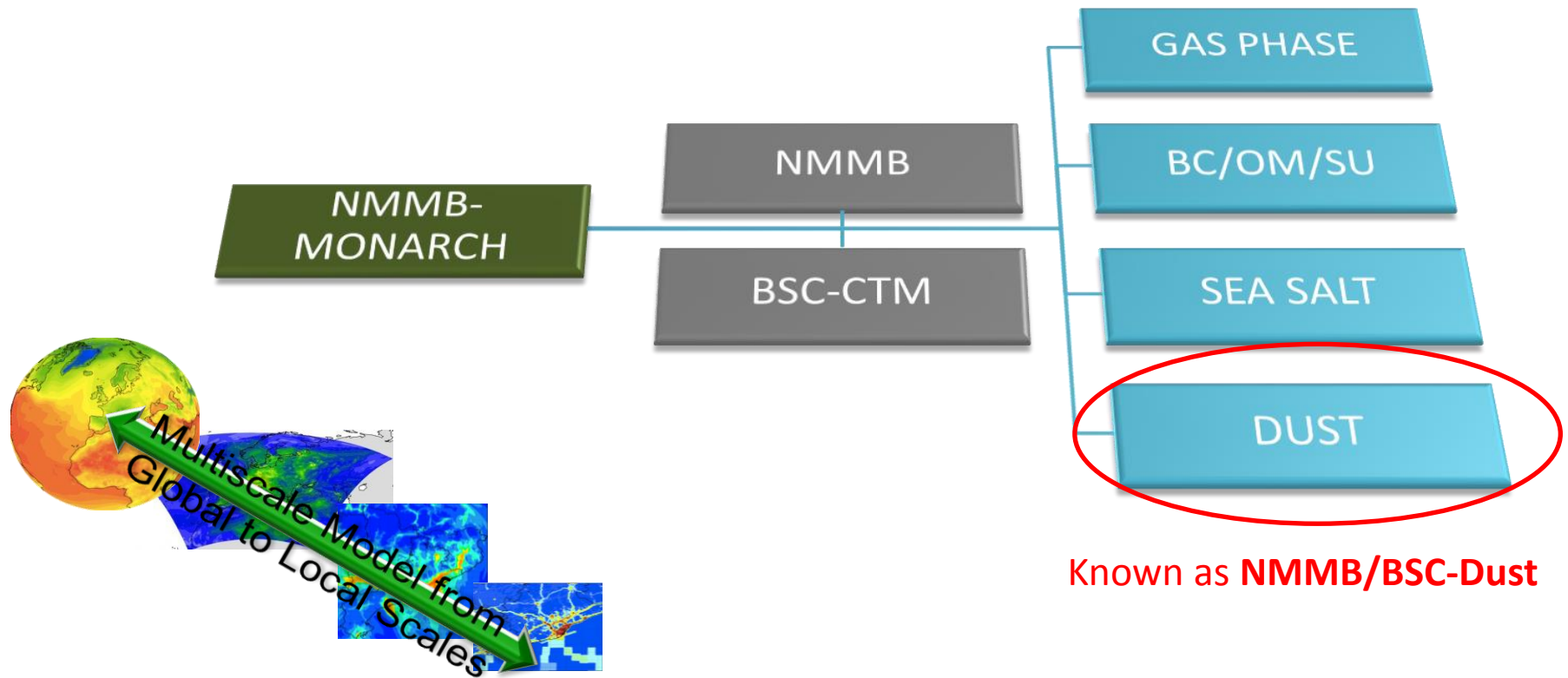
Europe (12 km, 480 x 400 cells)

Spain (4 km, 399 x 399 cells)

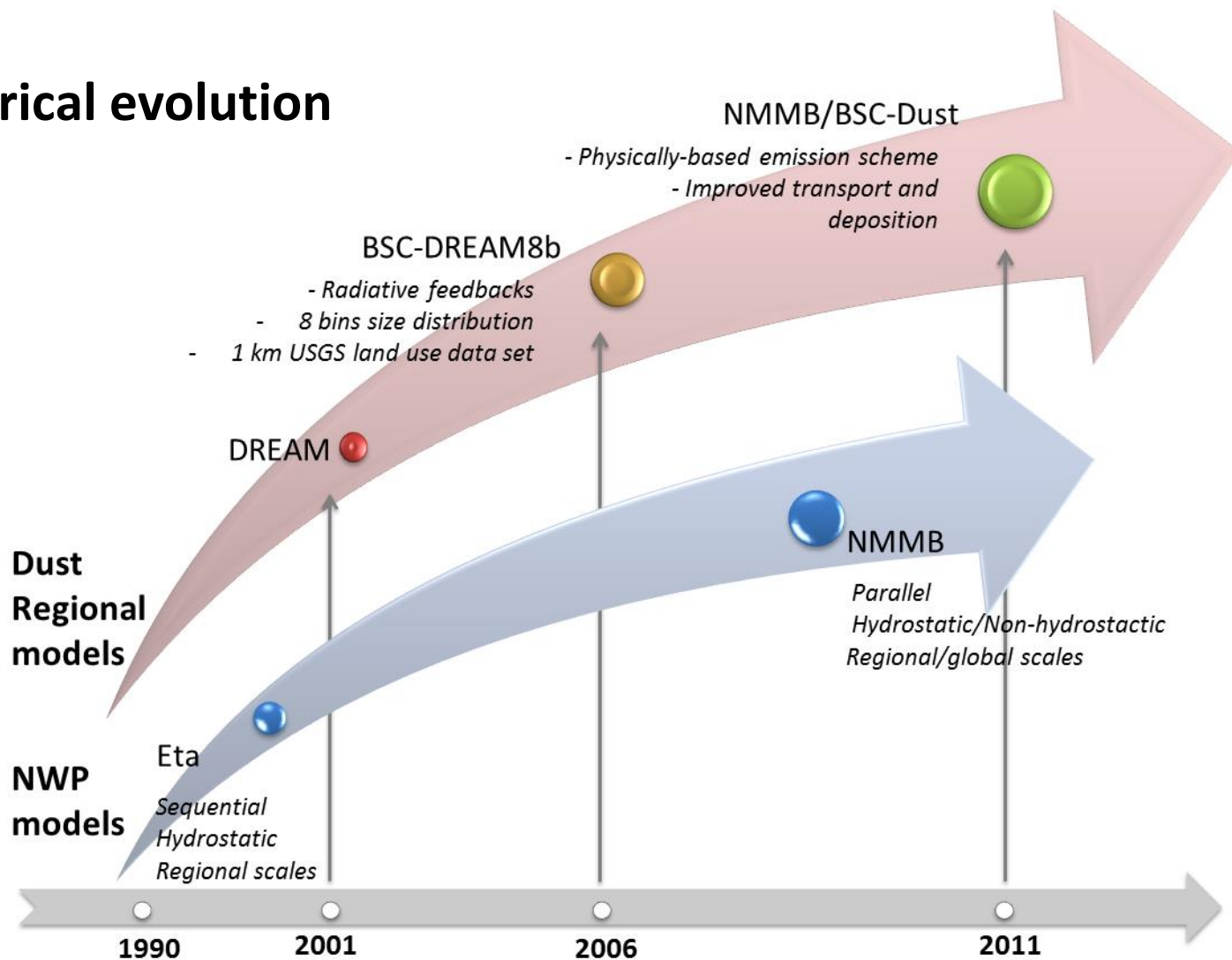




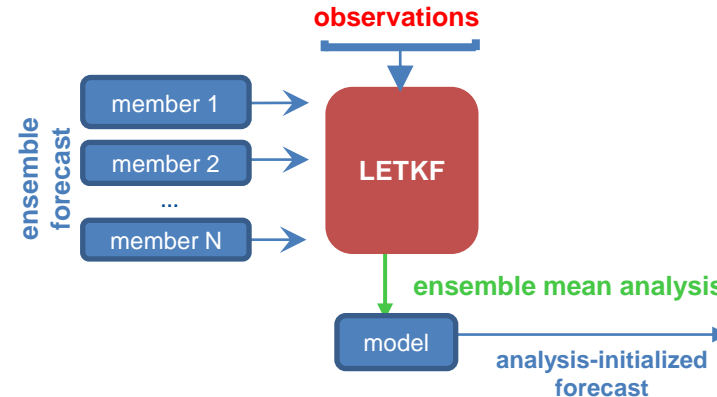
- The main system is build on the **meteorological driver NMMB**
- **Multiscale**: global to regional scales allowed (nesting capabilities)
- **Nonhydrostatic** dynamical core: single digit kilometre resolution allowed
- Fully **on-line** coupling: weather-chemistry feedback processes allowed
- Enhancement with a **data assimilation** system



## Historical evolution



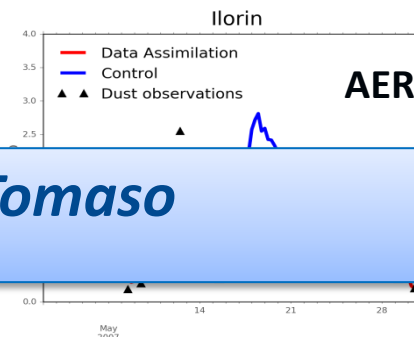
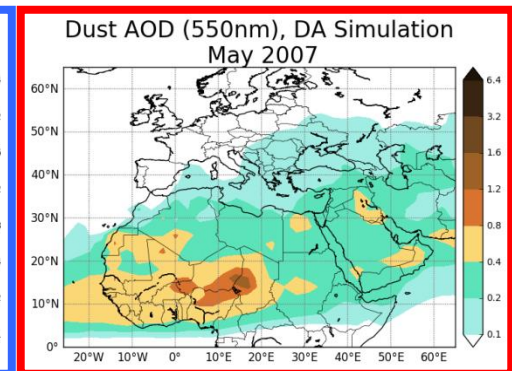
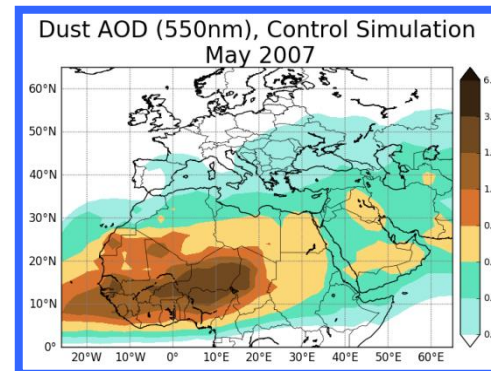
**NMMB-MONARCH** coupled with a Local Ensemble Transform Kalman Filter (**LETKF**) for the assimilation of aerosol optical depth observations



## Mineral dust application

The ensemble forecast is based on uncertainties in the dust emission scheme

- vertical flux,
- size distribution at emission
- threshold on friction velocity



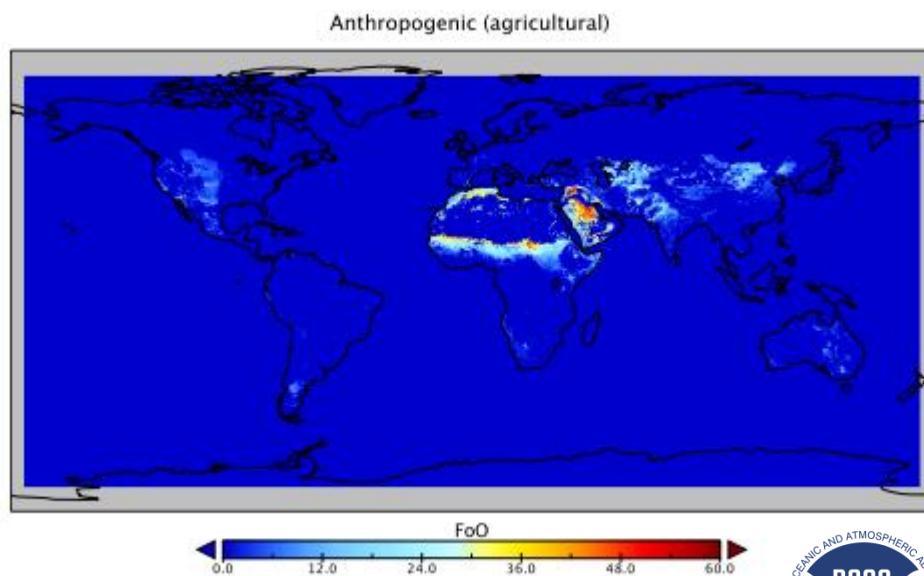
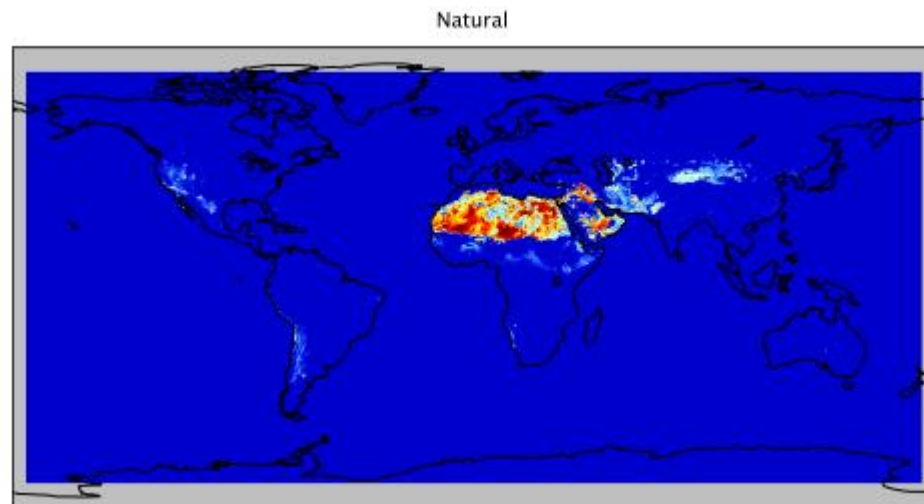
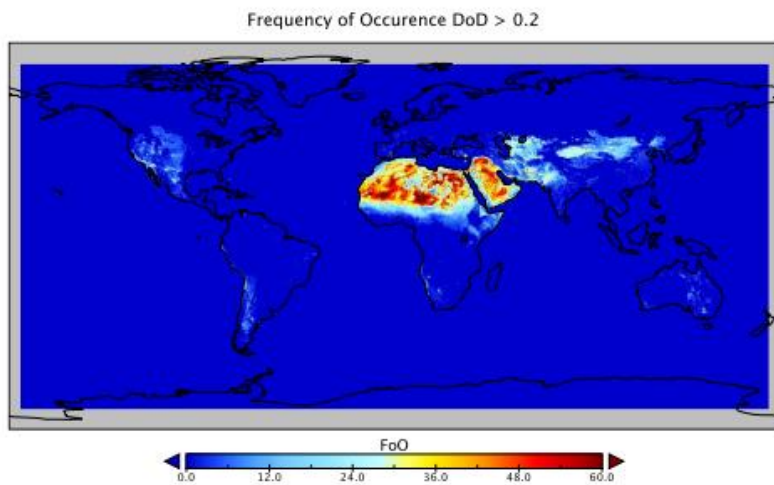
*Seminar by Enza Di Tomaso*

# Mineral dust: Dust Sources



## Understanding of the mineral dust sources

Natural and anthropogenic  
based on MODIS Deep



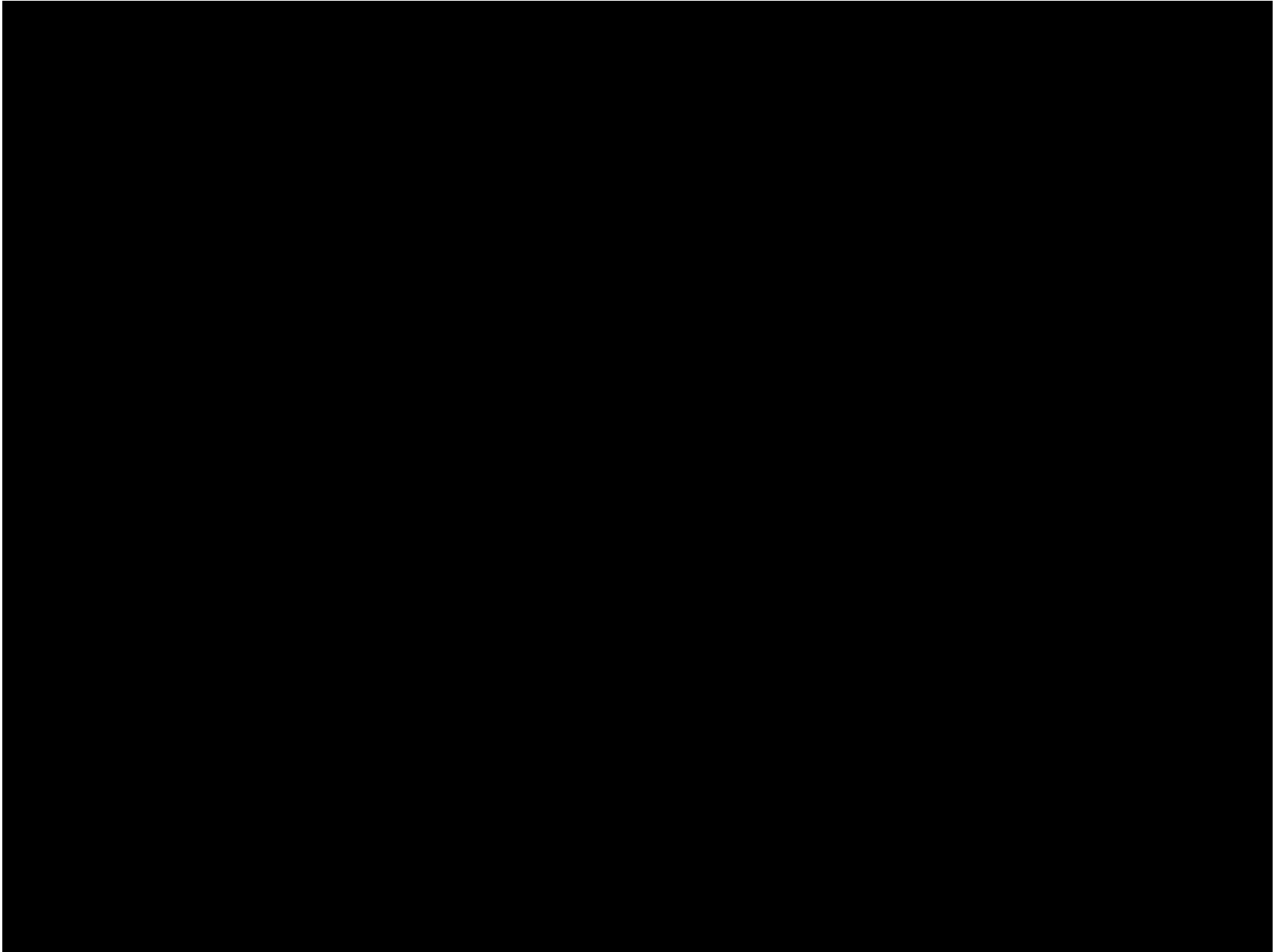
In collaboration P. Ginoux (NOAA-GFDL)

# Mineral dust: Topographical impacts



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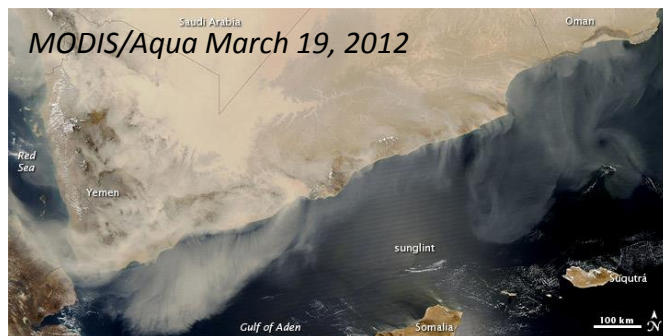
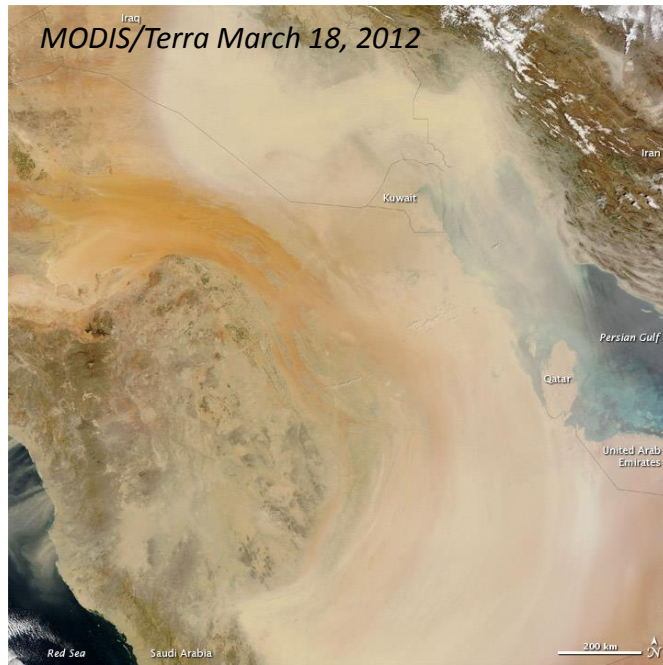




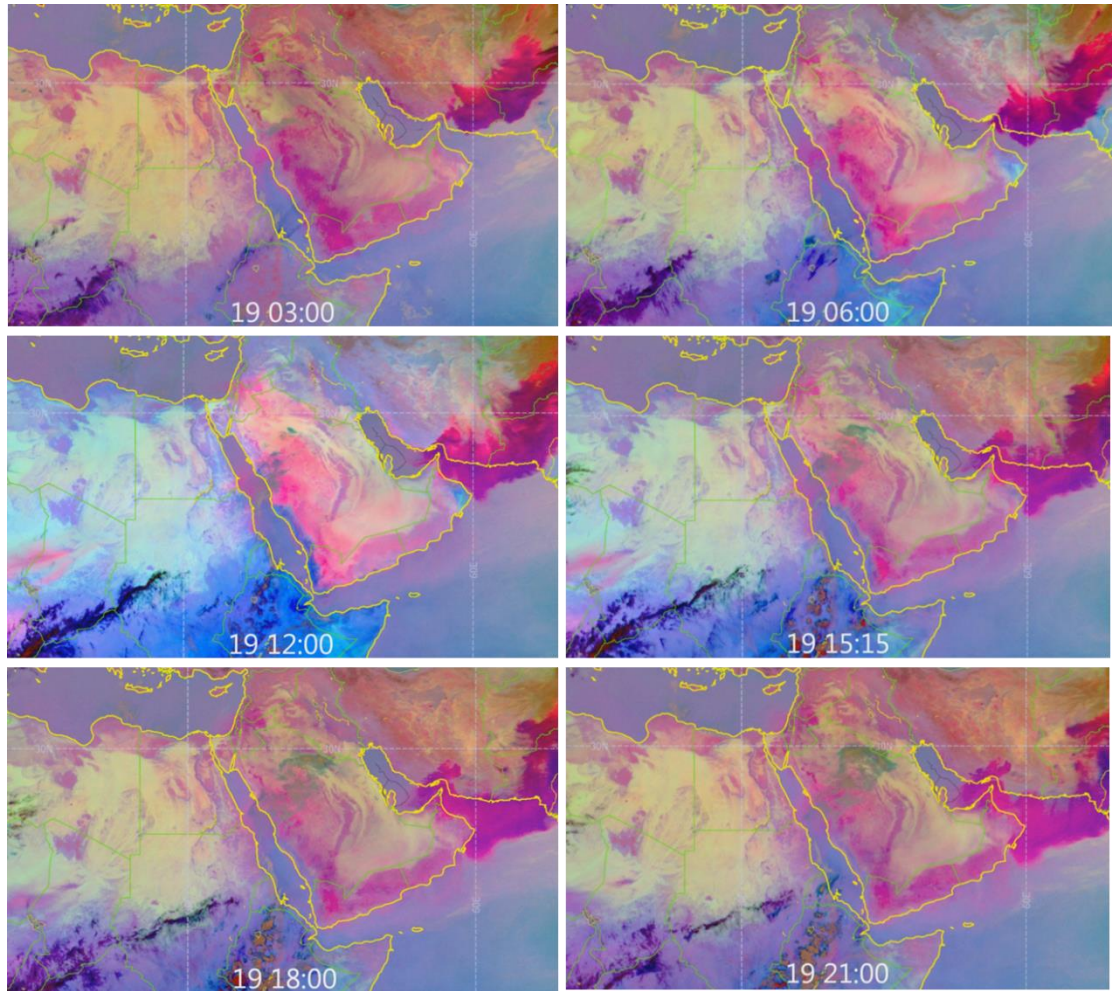
# Mineral dust: Topographical impacts



## *Impact of the topography on dust transport*



## *MSG/RGB March 19, 2012*

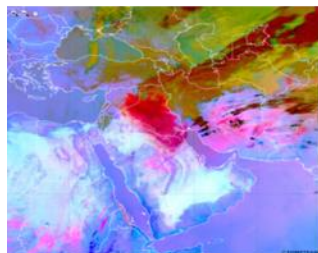


(Basart et al., Aeolian Research, 2016)

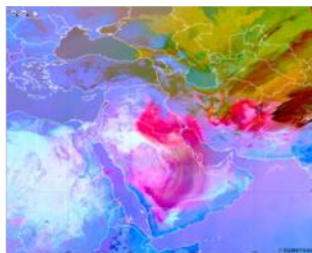


# Mineral dust: Topographical impacts

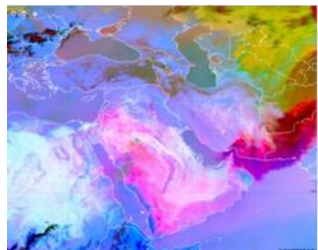
17 Mar 2012 12UTC



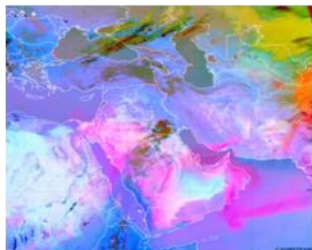
18 Mar 2012 12UTC



19 Mar 2012 12UTC

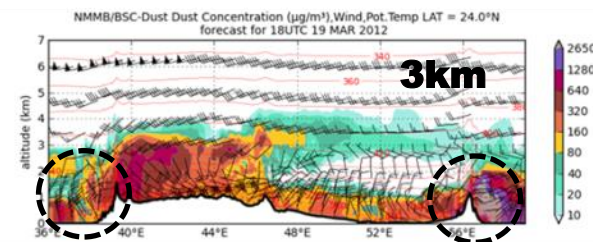
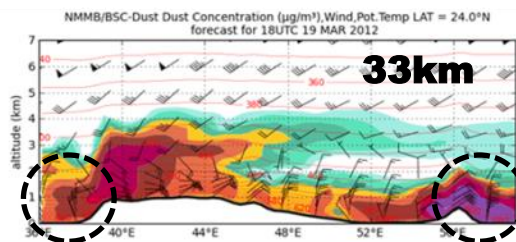
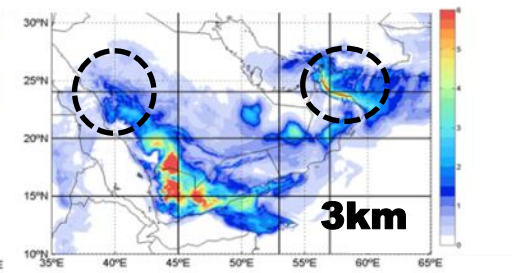
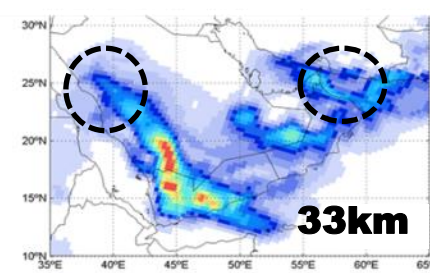
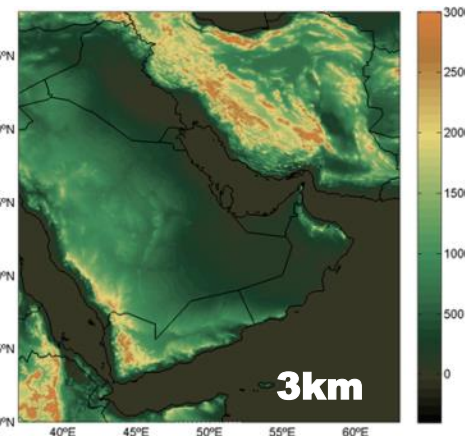
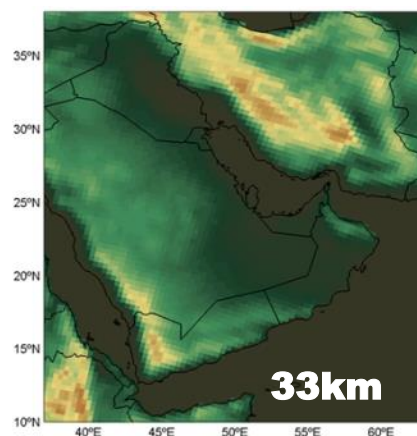


20 Mar 2012 12UTC



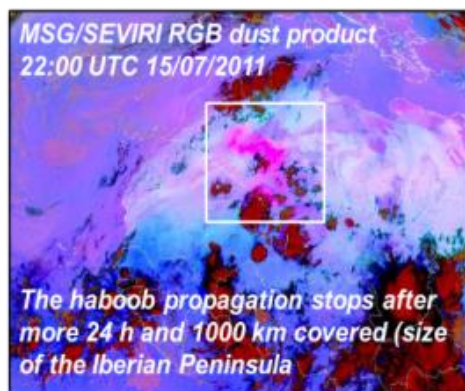
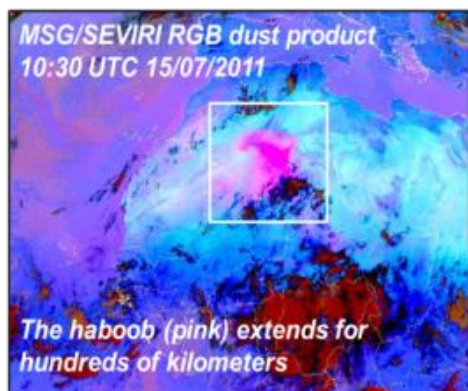
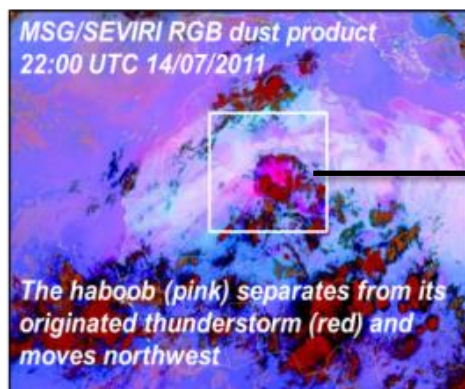
Two simulations using the **NMMB/BSC-Dust** model demonstrates results demonstrate how the dust prediction in the vicinity of complex terrains improves using high-horizontal resolution simulations.

**NMMB/BSC-Dust 19-March-2012 18UTC**





# Mineral dust: Haboobs (with explicit convection)



## MODEL CONFIGURATION

**Study domain:** 6°W-10°E to 15°N-31°N

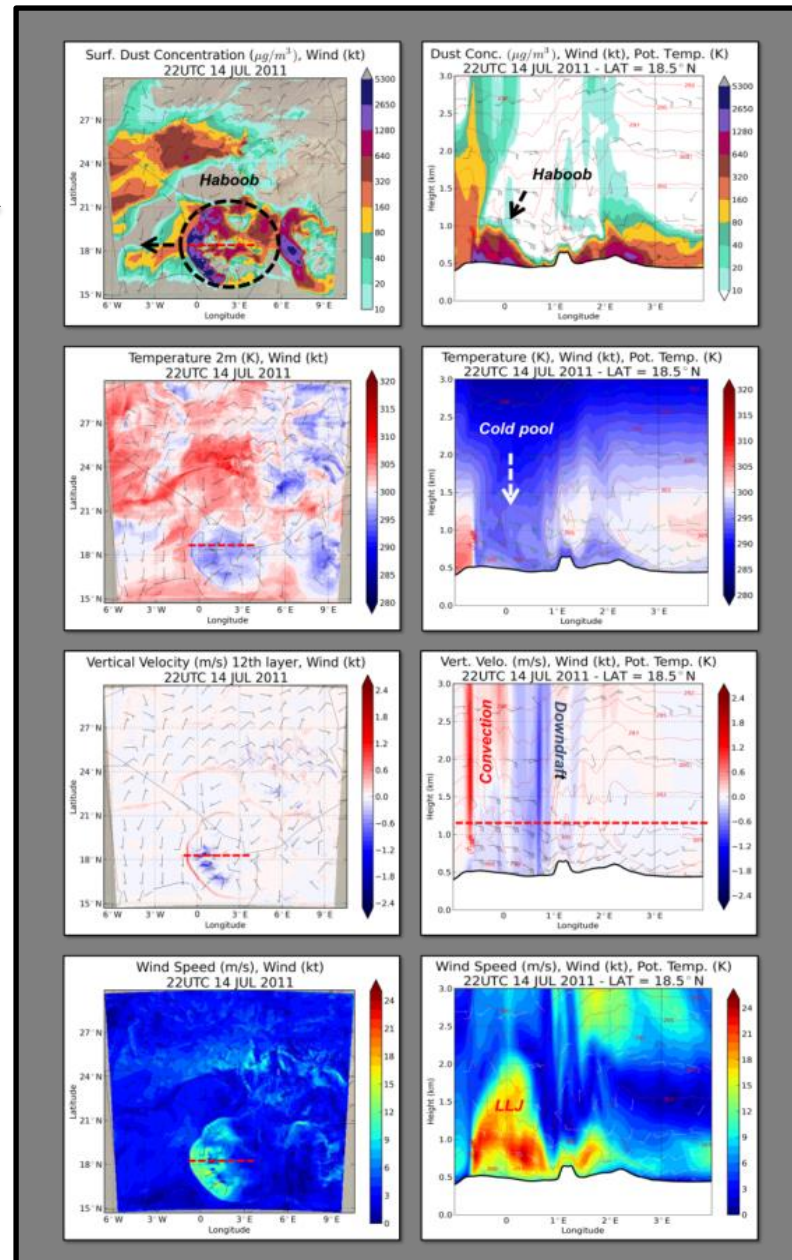
**Study period:** from 14 to 15 July 2011

**Horizontal resolution:** 0.03°x0.03° (about 3 km)

**Vertical resolution:** 60σ-layers (12-15σ-layers in the first 1000 m)

**Cold start** (No data assimilation)

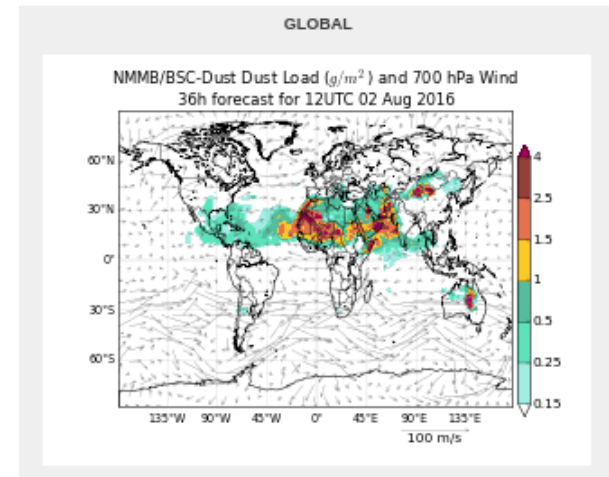
(Vendrell et al., in preparation)



## Daily dust operational forecast (global and regional domains)

<http://www.bsc.es/ESS>

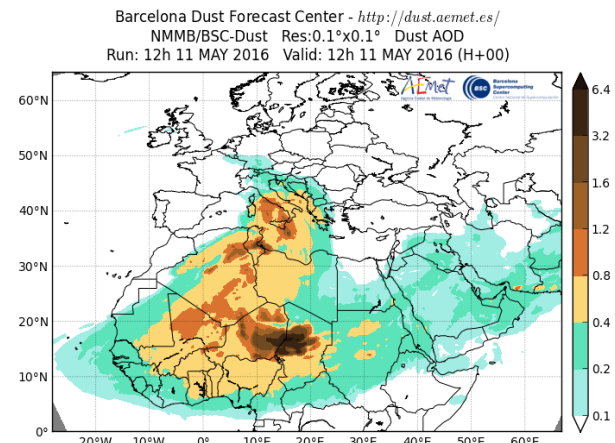
✓ Contribution to the **ICAP** multi-model ensemble  
(global) <http://icap.atmos.und.edu>



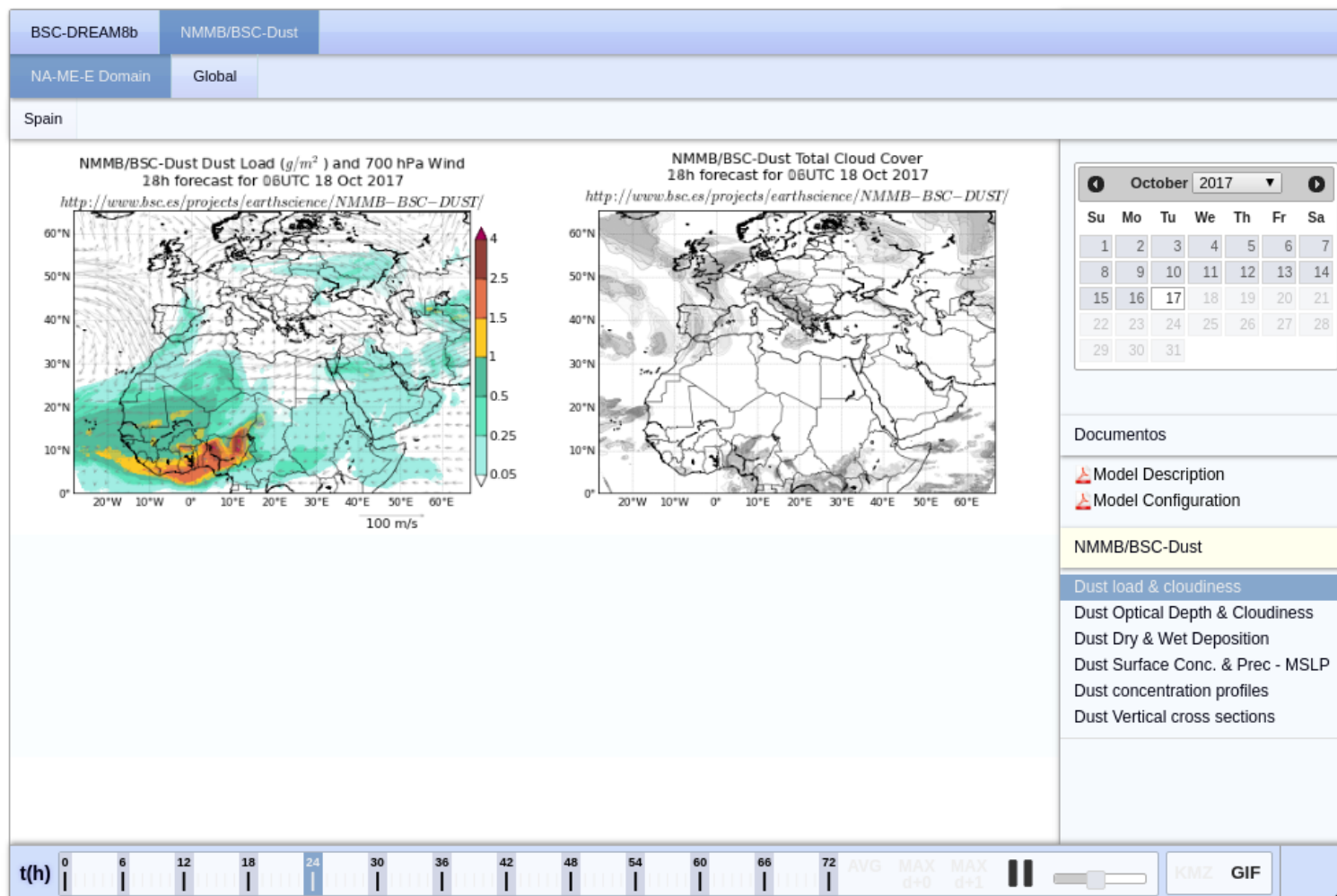
## WMO Dust Centers

**SDS-WAS. North Africa, Middle East and Europe  
Regional Center.** <http://sds-was.aemet.es>  
started in 2010 – **Research**

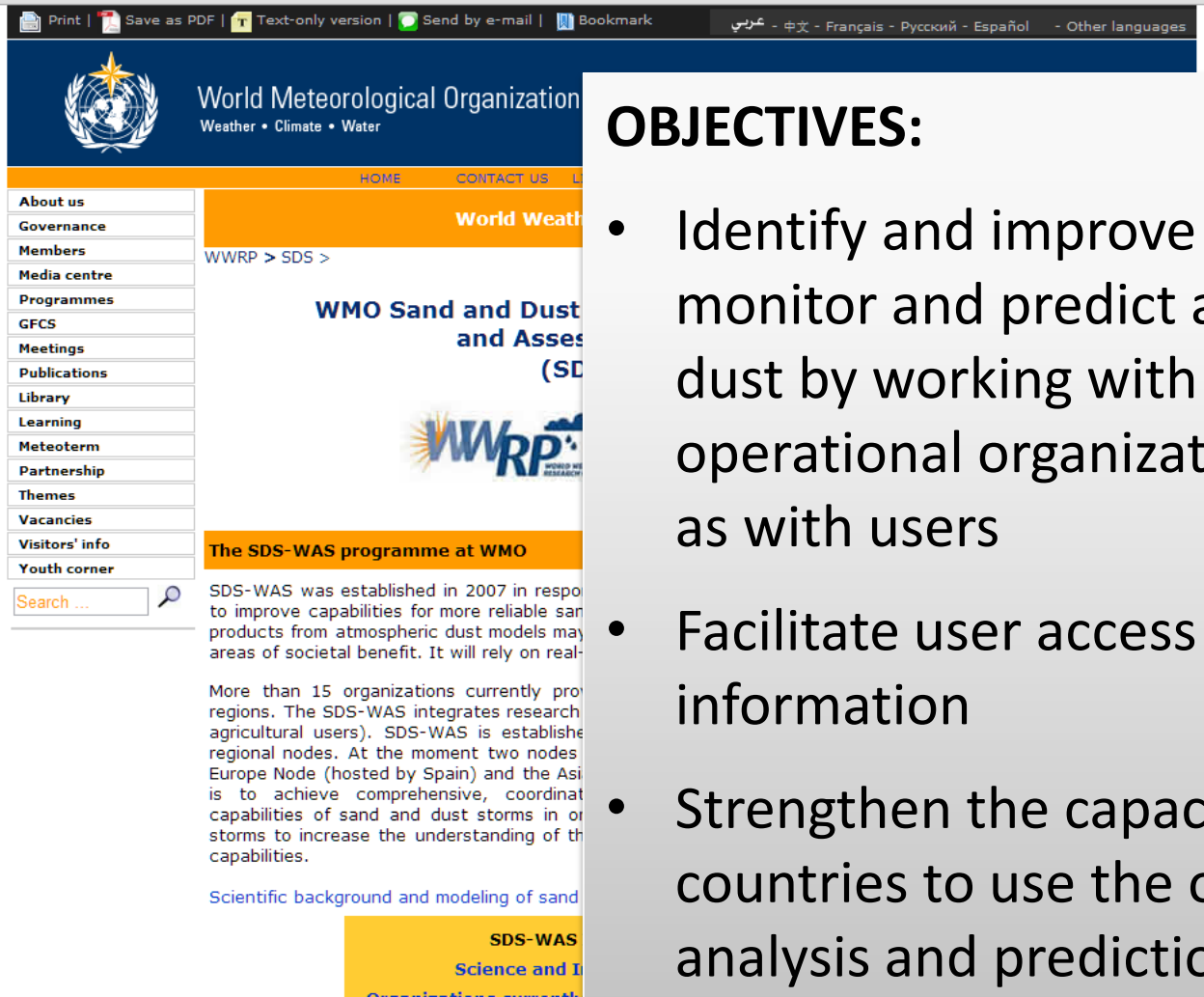
**Barcelona Dust Forecast Center.**  
First specialized WMO Center for mineral dust prediction.  
<http://dust.aemet.es> started in 2014 - **Operational**



## Daily dust operational forecast







The screenshot shows the WMO SDS-WAS project website. At the top, there is a navigation bar with links for 'Print', 'Save as PDF', 'Text-only version', 'Send by e-mail', and 'Bookmark'. Below this is a language selection bar with options for 'عربي', '中文', 'Français', 'Русский', 'Español', and 'Other languages'. The main header features the WMO logo and the text 'World Meteorological Organization Weather • Climate • Water'. A left sidebar contains a menu with items like 'About us', 'Governance', 'Members', 'Media centre', 'Programmes', 'GFCS', 'Meetings', 'Publications', 'Library', 'Learning', 'Meteoterm', 'Partnership', 'Themes', 'Vacancies', 'Visitors' info', and 'Youth corner'. The main content area has an orange banner for 'World Weather' and a sub-header 'WWRP > SDS >'. Below this is a section titled 'WMO Sand and Dust and Assessment (SD)' with a WWRP logo. A yellow box highlights 'The SDS-WAS programme at WMO'. The text describes the establishment of SDS-WAS in 2007 to improve capabilities for more reliable sand products from atmospheric dust models. It mentions that more than 15 organizations currently provide data from various regions, and SDS-WAS integrates research and operational capabilities. A search bar is located at the bottom left of the main content area.

## OBJECTIVES:

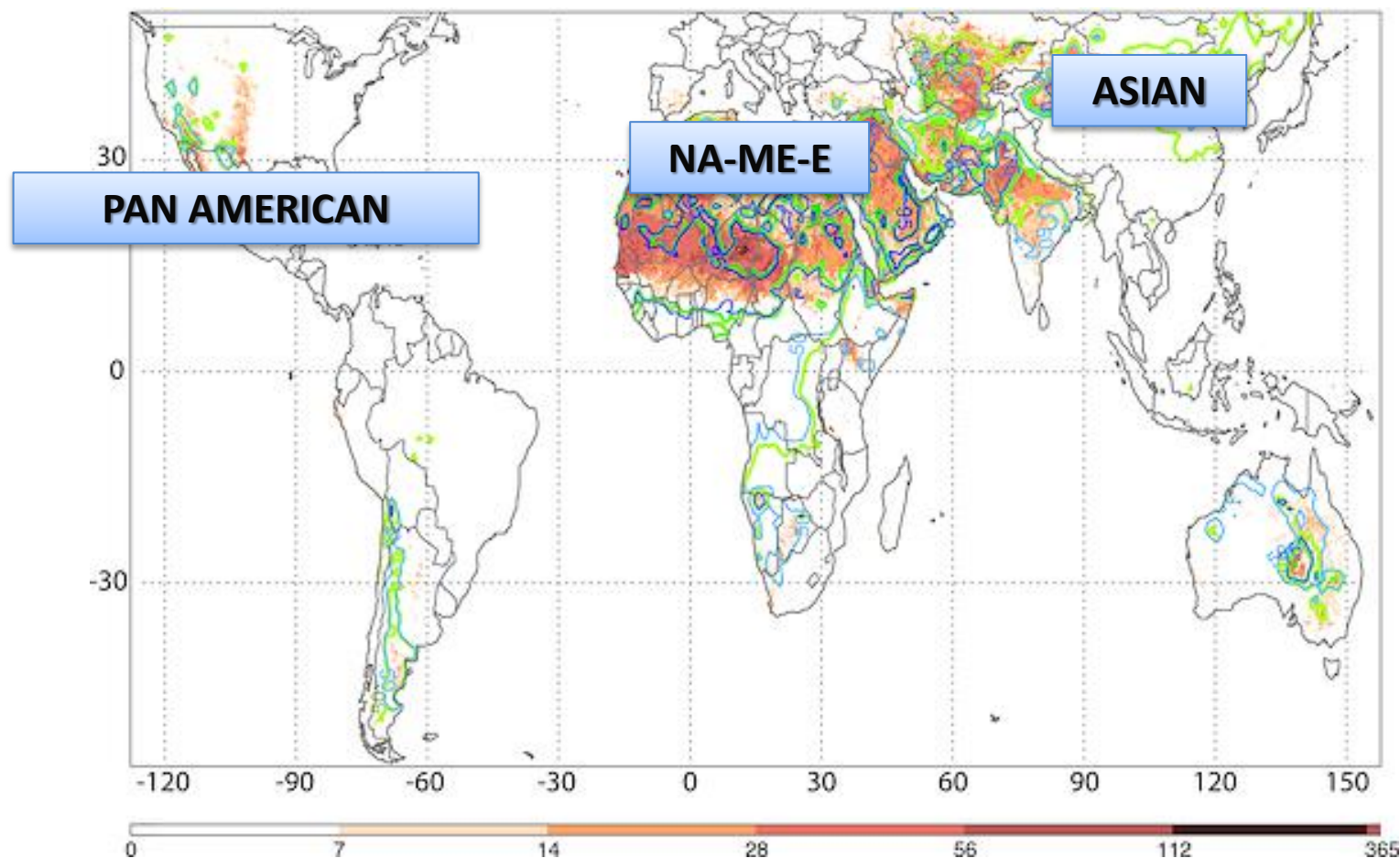
- Identify and improve products to monitor and predict atmospheric dust by working with research and operational organizations, as well as with users
- Facilitate user access to information
- Strengthen the capacity of countries to use the observations, analysis and predictions provided by the WMO SDS-WAS project

# The SDS-WAS Regional Centers




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Annual mean frequency distribution of M-DB2 (2003–2009) DOD > 0.2 (red), TOMS (1980–1991) aerosol index  $\geq 0.5$  (blue), and OMI (2004–2006) aerosol index  $\geq 0.5$  (green). The isocontours of TOMS and OMI have been removed over oceans for clarity.


Extracted from Ginoux et al. (2012, Rev. Geophys.)




WMO Sand and Dust Storm Warning Advisory and Assessment System(WMO SDS-WAS)  
**ASIA/CENTRAL PACIFIC REGIONAL CENTRE**


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**FORECAST**




**Concentration**  
Movies of surface dust concentration distribution over Asia in 3 hours interval for 3 days forecast from the model CUACE/Dust.

**CUACE/DUST OF CMA** [see more>>](#) [+ MORE](#)



**MASINGAR OF JMA** [see more>>](#) [+ MORE](#)




**ADAM OF KMA** [see more>>](#) [+ MORE](#)


**News & Event**

- >>Severe Solar Blast Affects China's Communication
- >>Science Steering Committee
- >>Workshop on the Implementation of the WMO SDS-WAS Asia Node (28-30 October 2009, Seoul, Korea)
- >>Workshop on the Implementation of the WMO SDS-WAS Asia Node


**OBSERVATION**


**PM10**





**AOD**






**Satellite Observation**



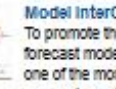


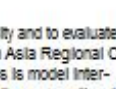






**MODEL COMPARISON**



**Model InterComparison**  
To promote the SDS forecast ability and to evaluate SDS forecast models representation in Asia Regional Center, one of the most important activities is model inter-comparison. At present there are three operational forecast models CUACE/Dust...

**LOGIN**

username

password

checking  
 0999

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**SDS COLOR INDEX**

No SDS
Suspended dust
Blowing sand
Sand And Dust Storm
Severe SDS
Extreme Severe SDS

**HOT LINKS**

- >> cma
- >> wmo sds was
- >> ca was
- >> cma
- >> narep regional center

**FORECAST DATA SHARING**

Download Forecast Data from





**The Center is managed by a consortium of AEMET and the Barcelona Supercomputing Center (BSC-CNS)**




**Nexus II Building. Barcelona**



**MareNostrum supercomputer**





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## NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER

WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

  
 World Meteorological Organization  
Weather • Climate • Water

  
 GOBIERNO DE ESPAÑA  
Ministerio de Agricultura, Pesca y Alimentación

  
 Aemet  
Agencia Estatal de Meteorología

  
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**Search**

**Latest News**

[Paper on dust emission recently published](#)

Oct 19, 2016

[Recent paper on cloud ice caused by dust](#)

Oct 13, 2016

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by Francisco Benincasa last modified: May 23, 2012 03:23

[SDS-WAS STUDIES](#)  
[OTHER PROJECTS](#)  
[AEROSOL ASSOCIATION](#)

**Outstanding**

Recent paper on cloud ice caused by dust

Paper on topographic impacts recently published

Aerosol climatology in Dakar recently published

TNO contributes to SDS-WAS

Global Assessment of Sand and Dust Storms

**Subscribe to the Public Newsletter!**

*To be informed about our activities, news and events related to dust. Frequency is almost monthly.*

Full Name


Your email

Subscribe

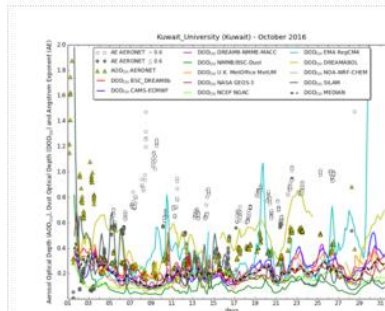
**Portal manual**

Please find a brief manual [here](#).

**Dust forecasts**



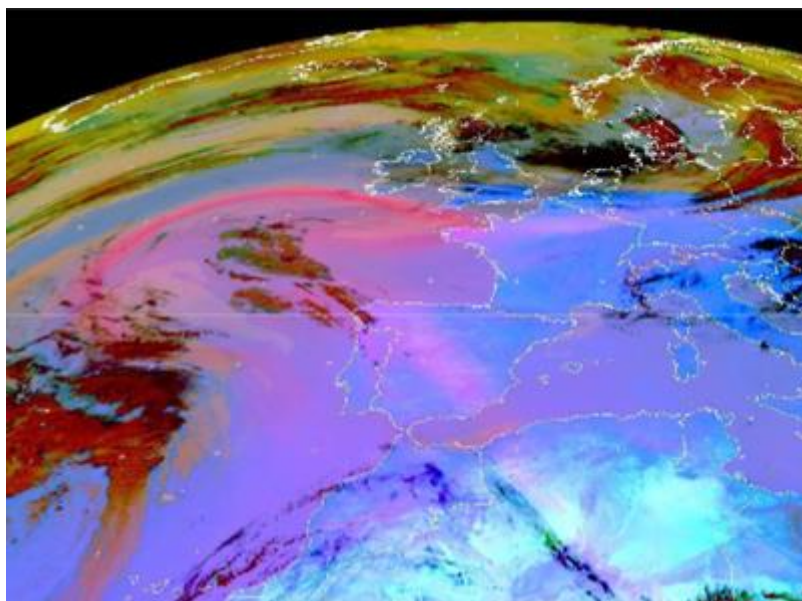
Compared Dust Forecasts



Forecast Evaluation



## European dust outbreak on April 2011



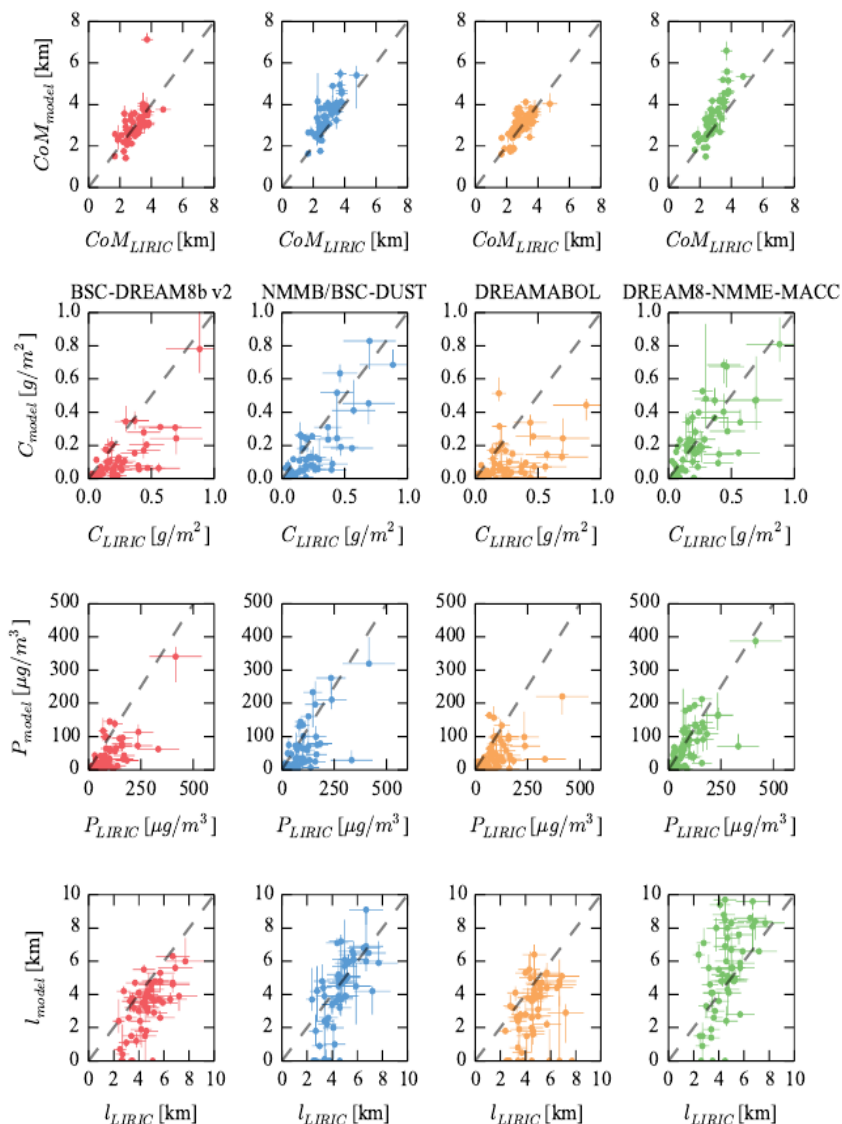
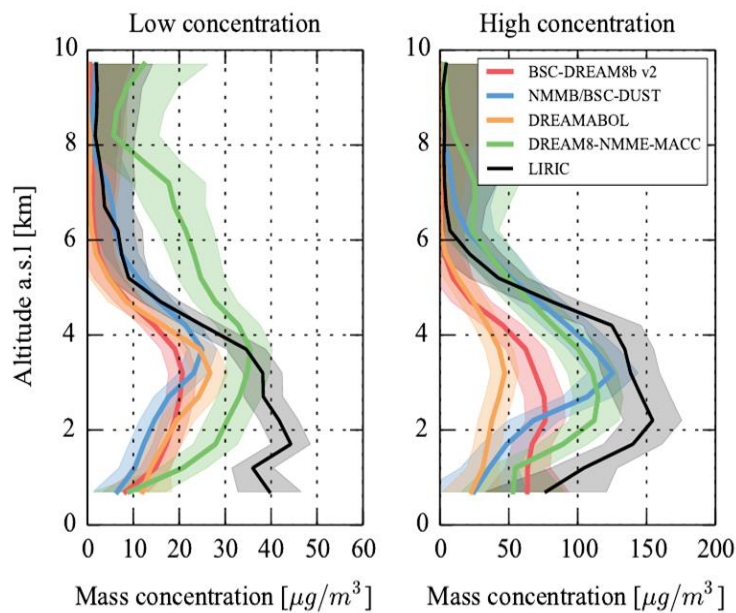
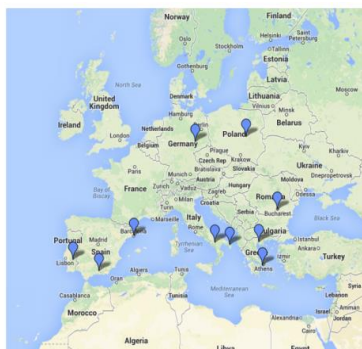
*MSG/SEVIRI RGB product 7 April  
Courtesy of EUMETSAT*

- The selected dust event corresponds to the one which occurred between the 5<sup>th</sup> and 11<sup>th</sup> of April of 2011.
- Participating models: BSC-DREAM8b, NMMB/BSC-Dust, ECMWF-MACC, UKMetOffice-UM and NMME-DREAM-MACC
- Comparison of each forecast (at 24, 48 and 72h) output to in-situ measurements of AOD (from AERONET), surface concentration (PM) and satellite retrieved AOD (MODIS, CALIPSO) and meteorology.

*(Huneus et al., ACP, 2016)*

# SDS-WAS NAMEE: Model intercomparison

## EARLINET vertical dust profiles: 2011-2013



(Biniatoglou et al., ATM, 2015)

# SDS-WAS NAMEE: Model intercomparison



The extreme dust storm occurred in Tehran (Iran) on **2<sup>nd</sup> June 2014** lasting less than 2 hours according to public evidence.

Based on public news, the dust storm caused several deaths, reduction of visibility to several tenths meters in the city, and adverse disturbance of the public traffic. The blowing wind reached 110 km/h.

This project aims to **better understand generation and development of small-scale dust storms** contributing so to exploring a potential of dust models to more accurately simulate such events, considering them as the most difficult ones to be operationally predicted.



# SDS-WAS NAMEE: Dust Forecasts



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WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

World Meteorological Organization

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Latest News

UN Envoy Supports Greenbelts in Iraq to Combat Sandstorms  
Feb 25, 2013

UNEP Global Environmental Alert Service releases 'Forecasting and early warning of dust storms'  
Feb 18, 2013

Scholarship on desert dust at the Univ. of Reading, UK

Multimodel

WMO SDS-WAS be a Regional Center

Forecast evaluation

Compared

Dust forecast

## FORECAST AND PRODUCTS

- Data exchange
- Joint visualization
- Common forecast evaluation
- Generation of multi-model products
- Calculation of monthly evaluation metrics
- New sources of data for model evaluation
- Sharing model output data files
- Time-averaged products



# SDS-WAS NAMEE: Dust Forecasts



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Dust prediction models provide 72 hours (at 3-hourly basis) of dust forecast (AOD at 550nm and surface concentration) covering the NAMEE region.



LSCE










MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b v2.0	12	Regional	No
CHIMERE	00	Regional	No
LMDzT-INCA	00	Global	No
CAMS-ECMWF	00	Global	MODIS AOD
DREAM8-NMME	00	Regional	CAMS analysis
NMMB/BSC-Dust	12	Regional	No
MetUM	00	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No
EMA REG CM4	12	Regional	No
DREAMABOL	12	Regional	No
NOA WRF-CHEM	12	Regional	No
FMI-SILAM	12	Global	No
TNO LOTOS	12	Regional	No



# SDS-WAS NAMEE: Files download



<b>BSC-DREAM8b v2.0</b>	<a href="#">DOWNLOAD FILES</a>	<a href="#">Model website</a>	 <b>Barcelona Supercomputing Center</b> Centro Nacional de Supercomputación
<b>MACC-ECMWF</b>	<a href="#">DOWNLOAD FILES</a>	<a href="#">Model website</a>	 <b>mac</b> Monitoring atmospheric composition & climate
<b>DREAM-NMME-MACC</b>	<a href="#">DOWNLOAD FILES</a>	<a href="#">Model website</a>	 <b>SEEVCCC</b>
<b>NMMB/BSC-Dust</b>	<a href="#">DOWNLOAD FILES</a>	<a href="#">Model website</a>	 <b>Barcelona Supercomputing Center</b> Centro Nacional de Supercomputación
<b>NASA-GEOS-5</b>	<a href="#">DOWNLOAD FILES</a>	<a href="#">Model website</a>	 <b>NASA</b>
<b>NCEP-NGAC</b>	<a href="#">DOWNLOAD FILES</a>	<a href="#">Model website</a>	 <b>NCEP</b> NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION
<b>Multimodel</b>			 <b>ALnet</b> Atmospheric Land-Use Network

Title	Size	Modified
<b>latest</b> - (download all)	4.0 kB	Apr 18, 2013 09:00 PM
<b>2013</b> - (download all)	4.0 kB	Apr 01, 2013 09:00 PM
<b>2012</b> - (download all)	4.0 kB	Apr 08, 2013 04:30 PM

- Daily forecasts of dust surface concentration and dust optical depth will be displayed on a page together with a menu to allow visualization of the archived products and/or download of the numerical files for a selected range of dates.
- Access to the download pages shall be restricted to those groups that authorize the exchange of their own data.



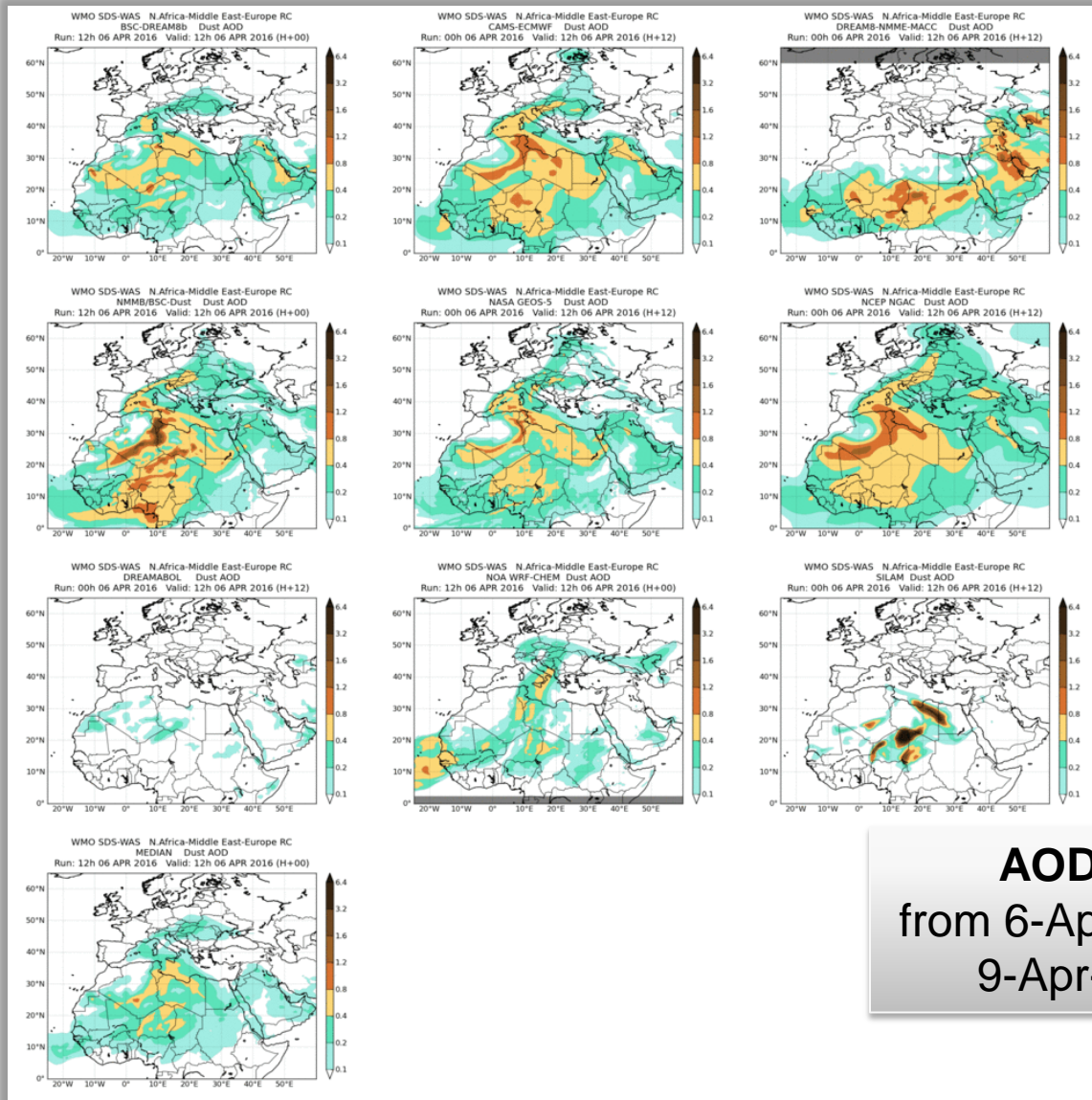
# SDS-WAS NAMEE: Joint visualization



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Agencia Estatal de Meteorología



**AOD at 550nm**  
from 6-Apr-2016 12:00 to  
9-Apr-2016 00:00

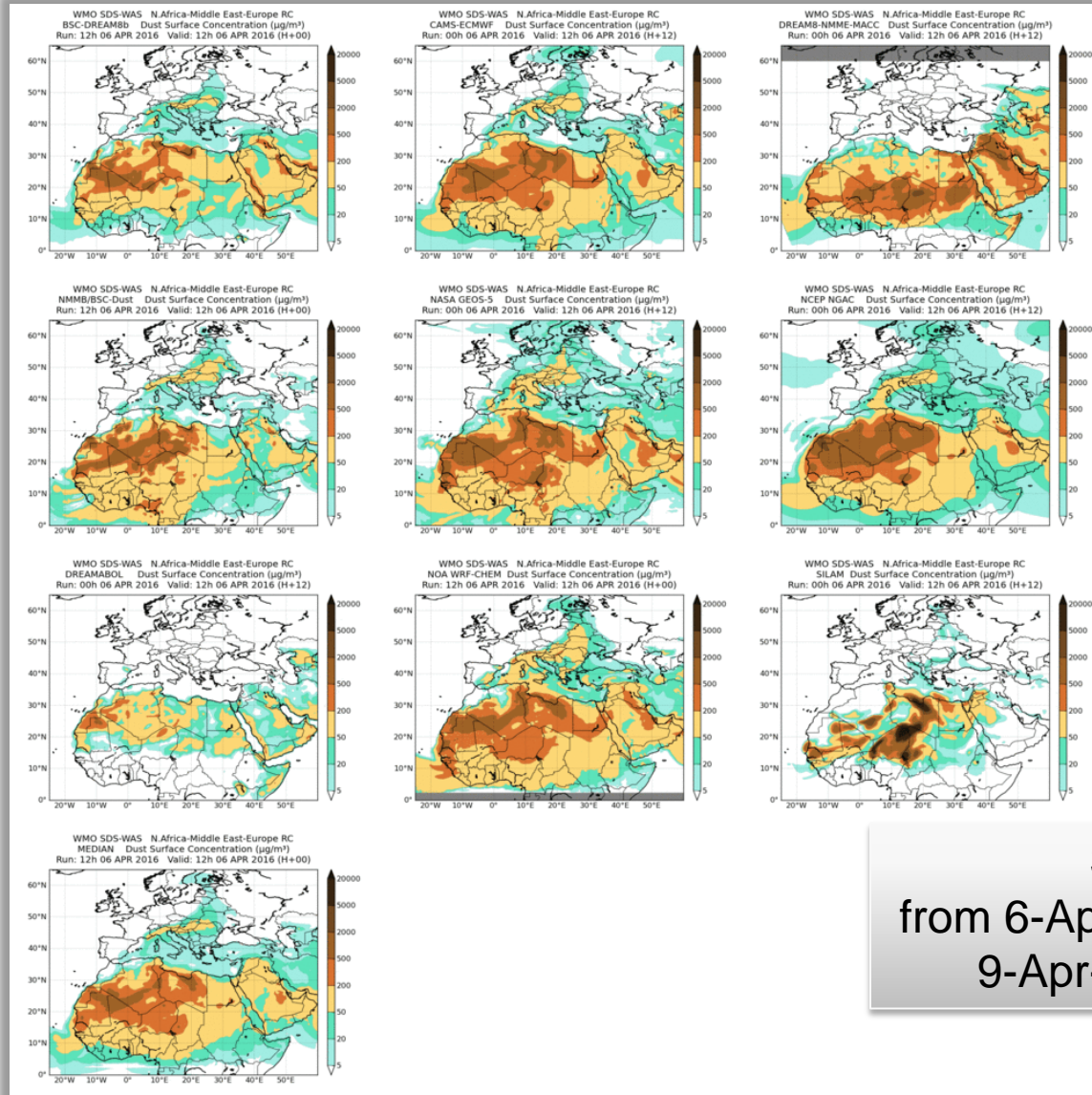
# SDS-WAS NAMEE: Joint visualization



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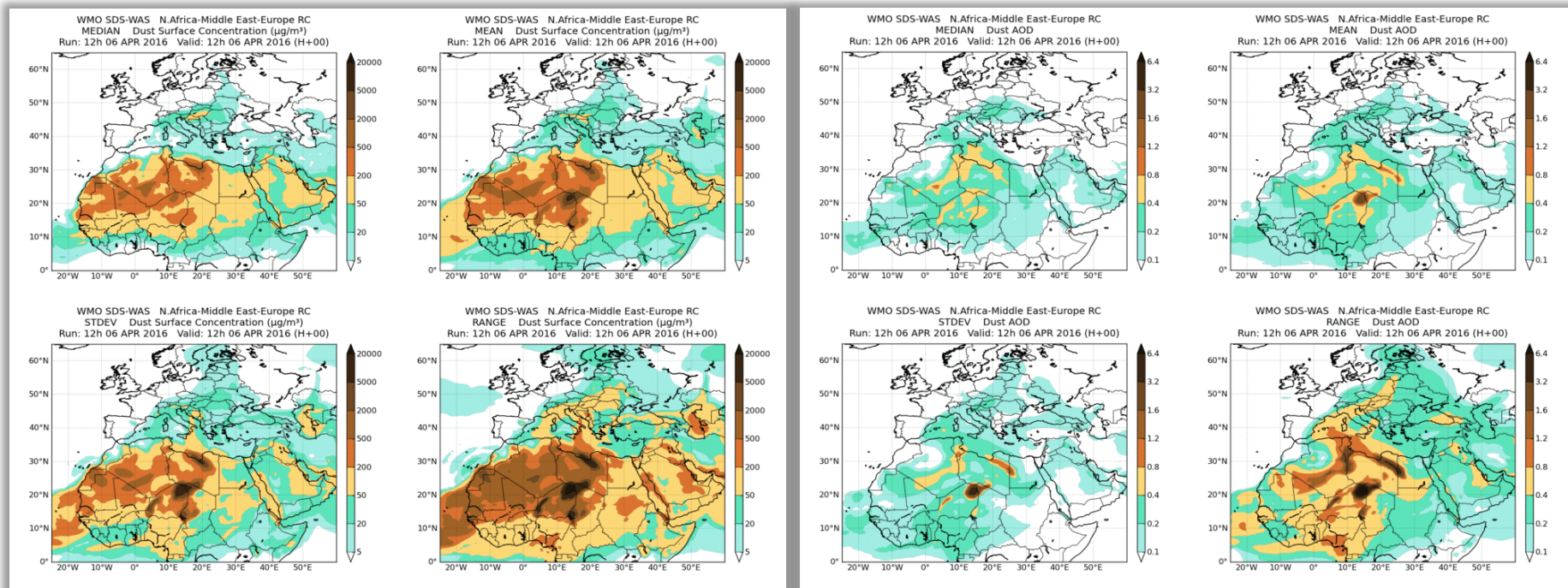
**SCON**

from 6-Apr-2016 12:00 to  
9-Apr-2016 00:00



## Surface concentration

## DOD at 550nm



from 6-Apr-2016 12:00 to 9-Apr-2016 00:00

Model outputs are bi-linearly interpolated to a common 0.5°x0.5° grid mesh. Then, different multi-model products are generated:

**CENTRALITY:** median - mean

**SPREAD:** standard deviation – range of variation

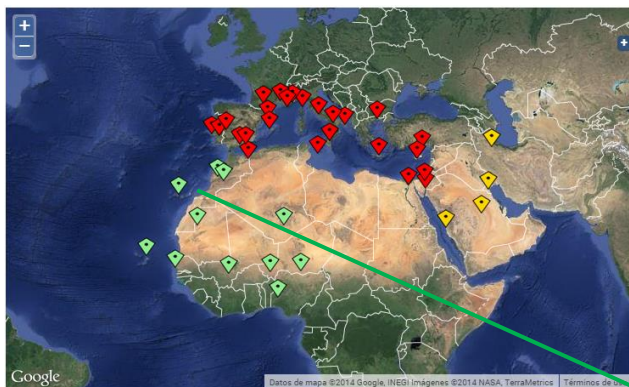
# SDS-WAS NAMEE: NRT AERONET



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OCHOA

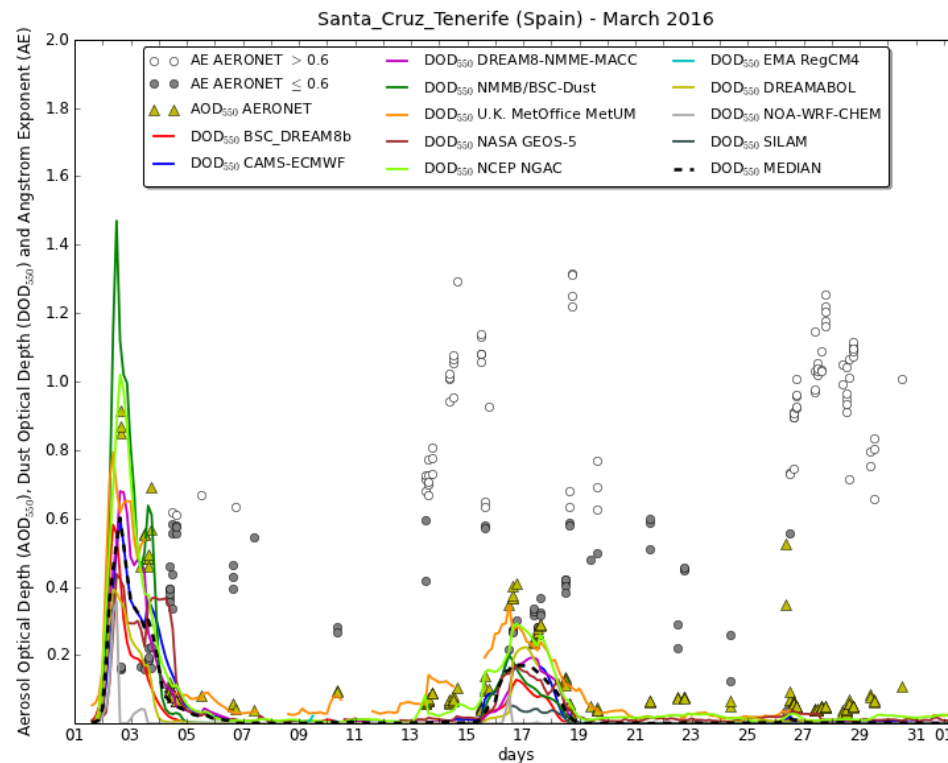
Aemet  
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A set of evaluation metrics are selected: ***Bias, RMSE, correlation coefficient and FGE***

Calculations evaluation metrics are done for:

- ***monthly/seasonal/annual***
- ***sites and regions***



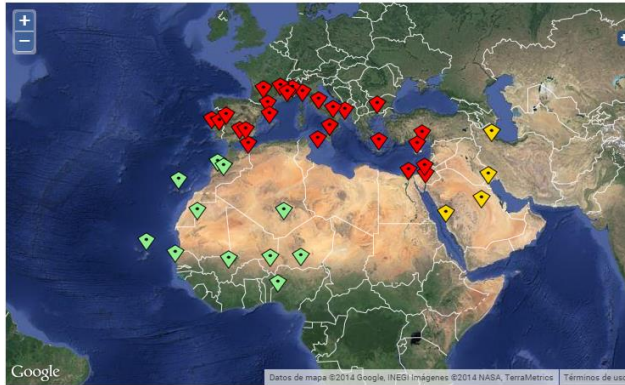
# SDS-WAS NAMEE: NRT AERONET



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A set of evaluation metrics are selected: **Bias, RMSE, correlation coefficient and FGE**

Calculations evaluation metrics are done for:

- **monthly/seasonal/annual**
- **sites and regions**

## Seasonal scores

by Francesco Benincasa — last modified Jan 14, 2016 04:52 PM

Date: - Select Year - - Select Season -

Dec 2015 - Feb 2016. Dust Optical Depth.  
Threshold Angstrom Exponent = 0.600

## BIAS

	BSC_ DREAMb	CAMS- ECMWF	DREAM-NMME- MACC	NMMR/BSC- Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF- CHEM	MEDIAN
Sahel/Sahara <a href="#">show stations</a>	-0.33	-0.17	-0.23	0.05	-0.06	-0.16	-0.10	0.10	-0.34	-0.25	-0.21
Middle East <a href="#">show stations</a>	-0.12	-0.03	-0.07	-0.25	-0.03	-0.15	-0.17	0.13	-0.22	-0.17	-0.16
Mediterranean <a href="#">show stations</a>	-0.17	-0.17	-0.15	-0.18	-0.09	-0.16	-0.13	-0.09	-0.16	-0.16	-0.16
TOTAL	-0.26	-0.17	-0.20	-0.04	-0.07	-0.16	-0.11	0.03	-0.27	-0.21	-0.19

## ROOT MEAN SQUARE ERROR

	BSC_ DREAMb	CAMS- ECMWF	DREAM-NMME- MACC	NMMR/BSC- Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF- CHEM	MEDIAN
Sahel/Sahara <a href="#">show stations</a>	0.54	0.41	0.51	0.42	0.36	0.37	0.38	0.66	0.56	0.53	0.43
Middle East <a href="#">show stations</a>	0.32	0.28	0.34	0.41	0.33	0.34	0.35	0.34	0.37	0.39	0.33
Mediterranean <a href="#">show stations</a>	0.32	0.33	0.30	0.32	0.30	0.31	0.30	0.40	0.31	0.34	0.31
TOTAL	0.46	0.38	0.44	0.39	0.34	0.35	0.35	0.57	0.48	0.47	0.39

## CORRELATION COEFFICIENT

	BSC_ DREAMb	CAMS- ECMWF	DREAM-NMME- MACC	NMMR/BSC- Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF- CHEM	MEDIAN
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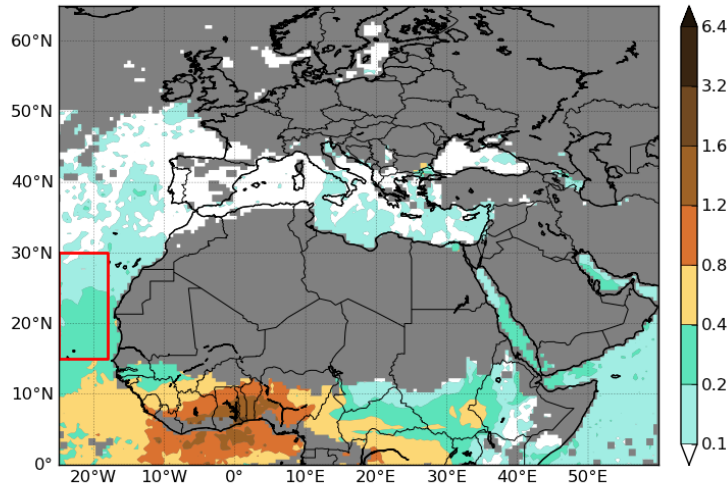
<http://sds-was.aemet.es/> 29



# SDS-WAS NAMEE: MODIS

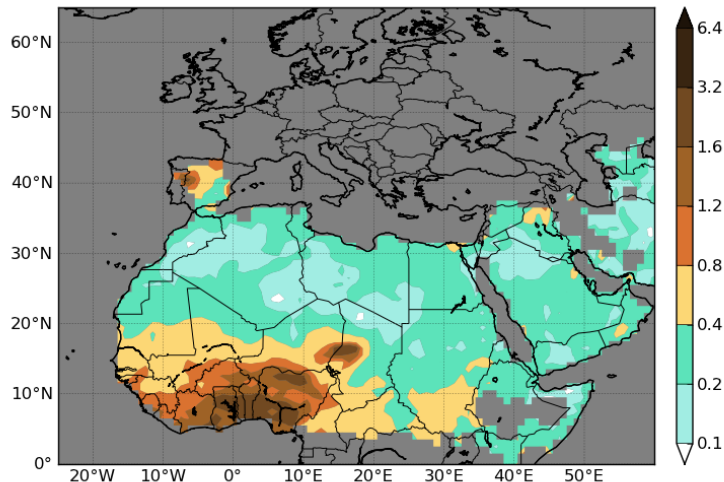


WMO SDS-WAS N.Africa-Middle East-Europe RC  
MODIS AOD<sub>550</sub> - DEC 2015 - FEB 2016



	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_DREAM8b	-0.24	0.43	0.63	1.07	207012
NMMB/BSC- Dust	-0.10	0.29	0.78	0.98	201353
NCEP NGAC	-0.12	0.32	0.68	0.71	207012
EMA RegCM4	0.11	0.54	0.29	0.94	39231
DREAMABOL	-0.21	0.44	0.36	0.96	198954
NOA-WRF- CHEM	-0.19	0.41	0.46	1.04	198463

WMO SDS-WAS N.Africa-Middle East-Europe RC  
MODIS DEEPBLUE AOD<sub>550</sub> - DEC 2015 - FEB 2016



	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_DREAM8b	-0.23	0.44	0.45	0.89	51308
NMMB/BSC- Dust	-0.11	0.34	0.78	1.03	47494
NCEP NGAC	-0.14	0.34	0.69	0.66	48659
EMA RegCM4	0.17	0.59	0.35	0.82	12050
DREAMABOL	-0.25	0.46	0.41	0.91	48036
NOA-WRF- CHEM	-0.22	0.43	0.48	1.03	51220



# SDS-WAS NAMEE: Model evaluation



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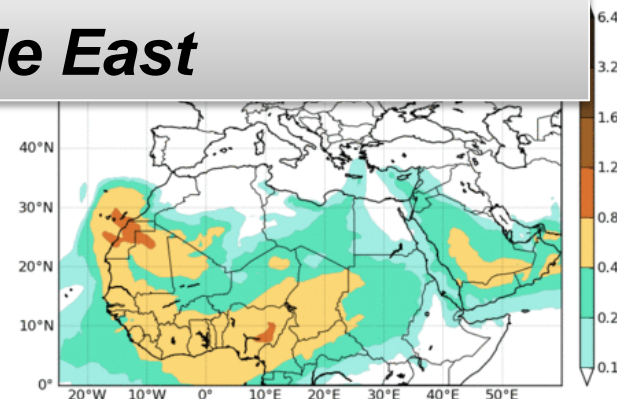


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7 March 2015

***New observational datasets for model evaluation in  
Northern Africa and Middle East***



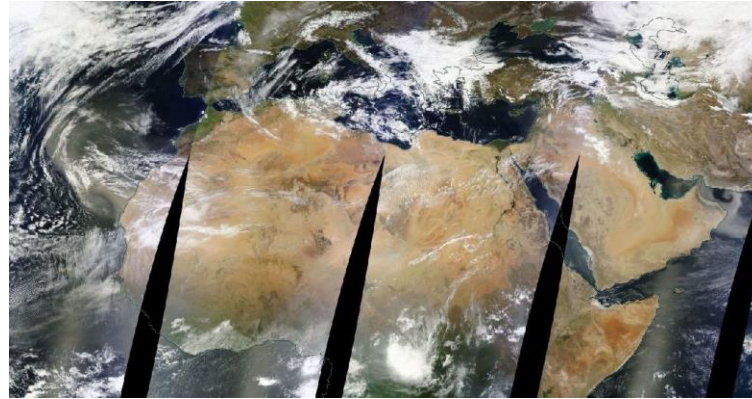
MET10 RGB-Dust 2015-03-07 23:00 UTC



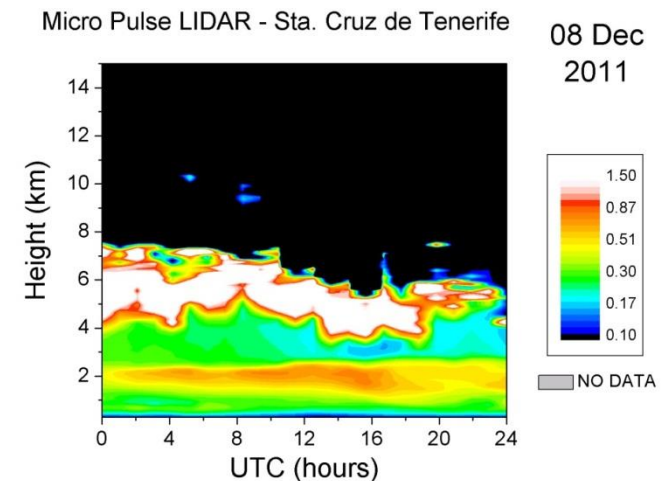
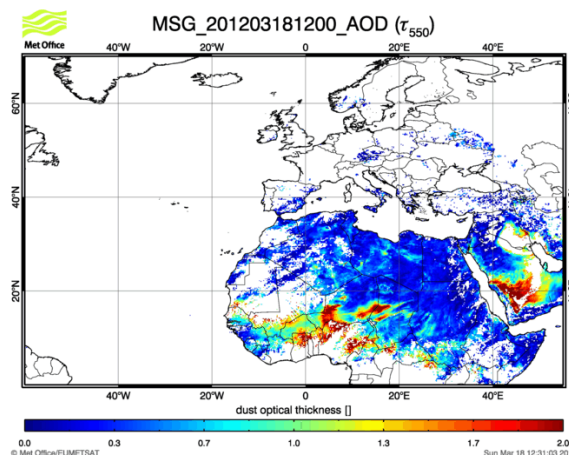
<http://sds-was.aemet.es/>

## ***New observational datasets for model evaluation in Northern Africa and Middle East***

- Visibility
- MSG/SEVIRI
- MODIS
- OMI
- CALIPSO
- PARASOL
- MPLNET
- PM<sub>10</sub>



*MODIS composite 8<sup>th</sup> March 2015 from EOSDIS World Viewer*





# SDS-WAS NAMEE: Model evaluation



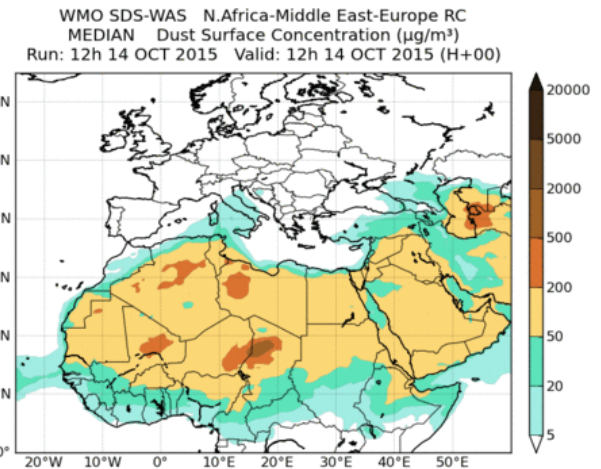
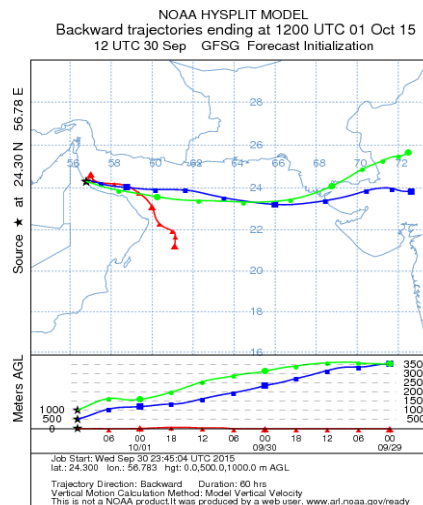
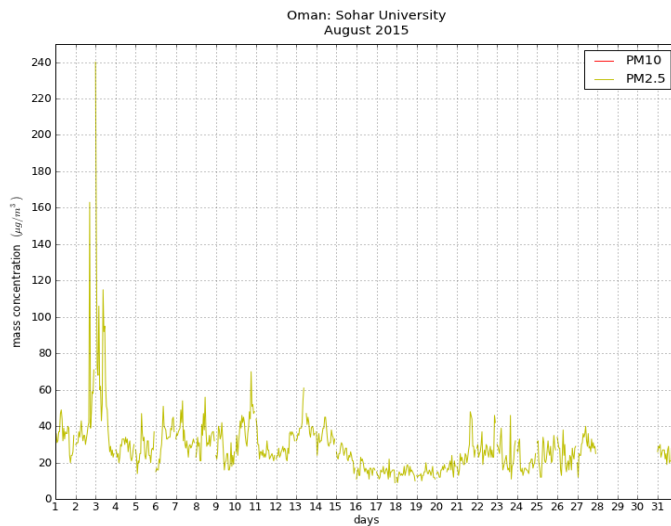
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## NRT surface concentration



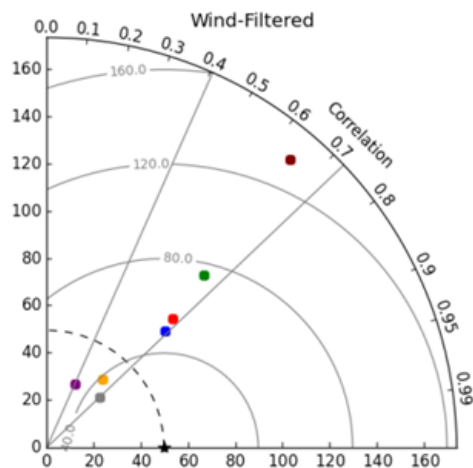
## AMMA network: PM10 in Sahel for the year 2013



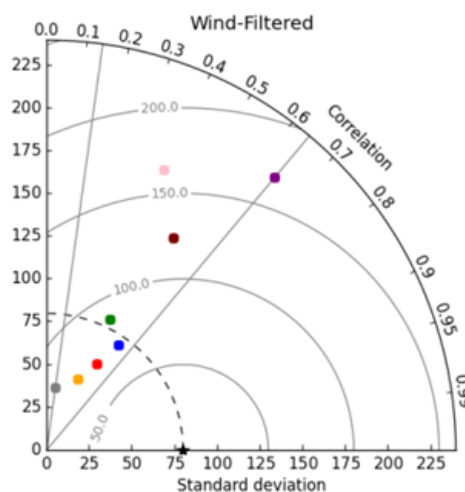
**Not all PM10 is dust:** Local and biomass burning from Savannah fires.

**Dust filter:** Considering the localizations of the desert dust sources the filter is based on wind direction.

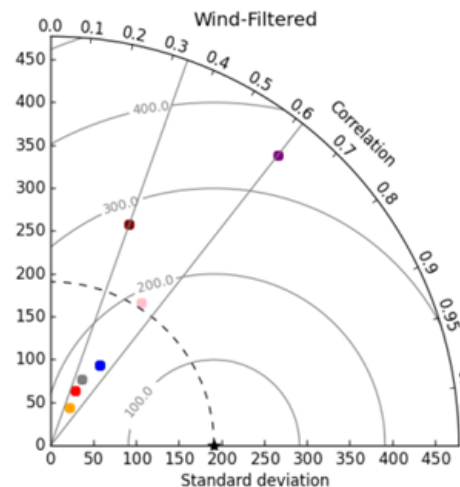
M'Bour-Senegal



Cinzana-Mali



Banizoumbou-Niger

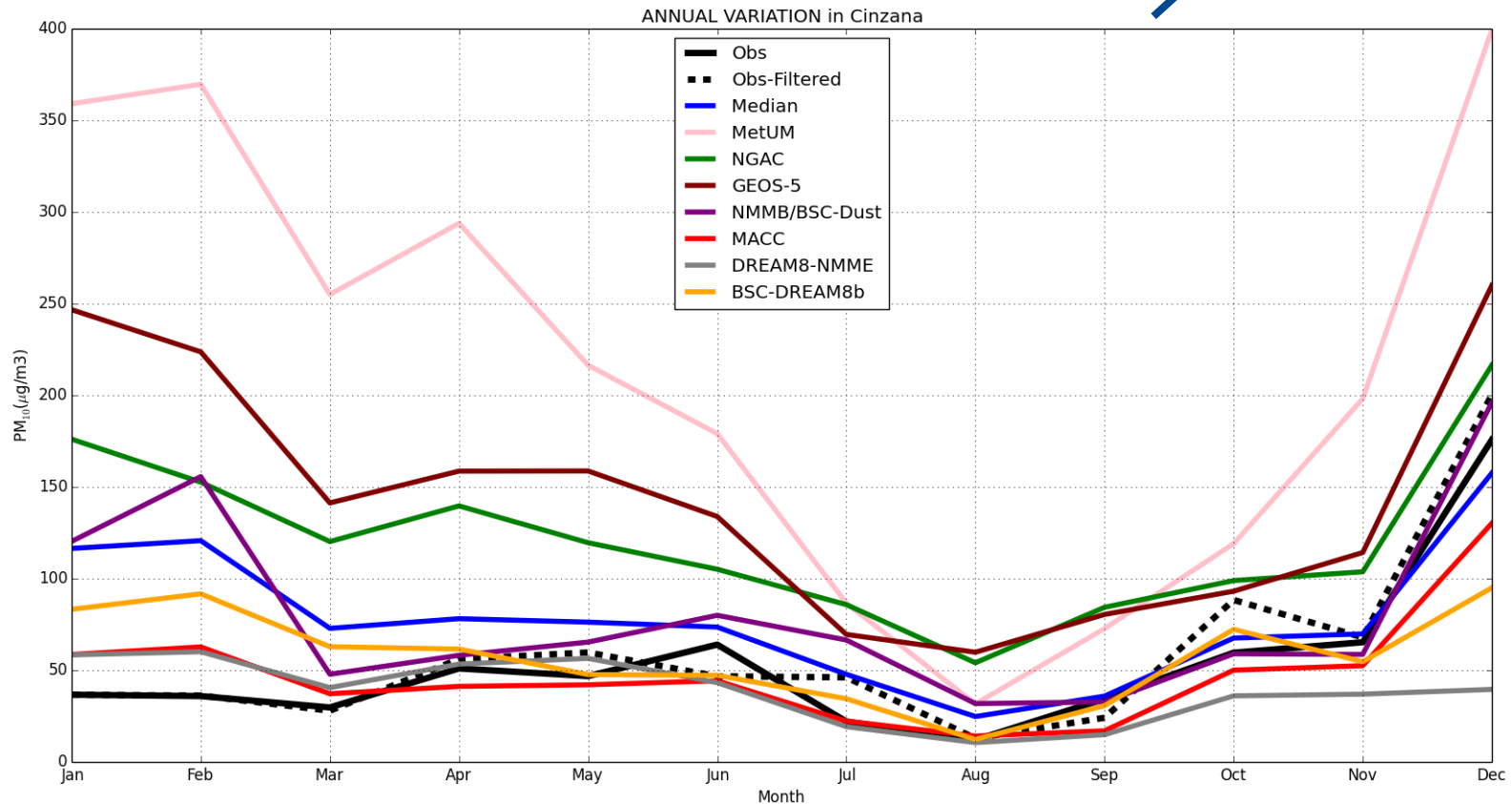


- ★ Reference
- CAMS
- Median
- NGAC
- NMMB/BSC-Dust
- BSC-DREAM8b
- GEOS-5
- MetUM
- DREAM8-NMME



# SDS-WAS NAMEE: Model evaluation

## AMMA network: PM<sub>10</sub> in Sahel for the year 2013



# SDS-WAS NAMEE: Model evaluation



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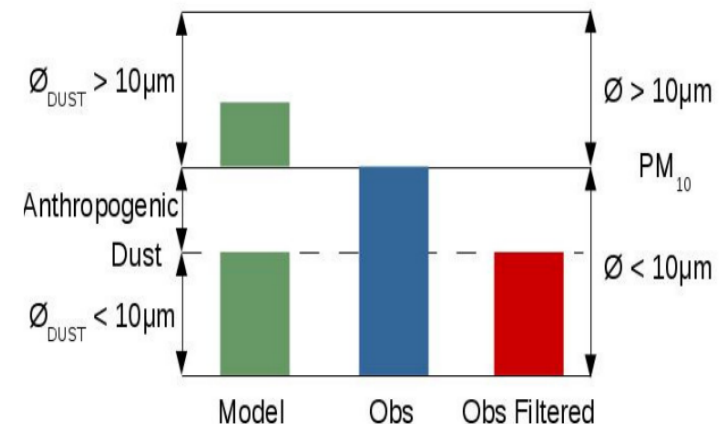
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## AQ network: Canary Islands 2013-2014



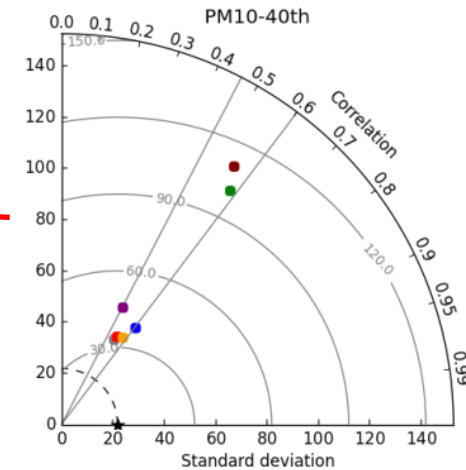
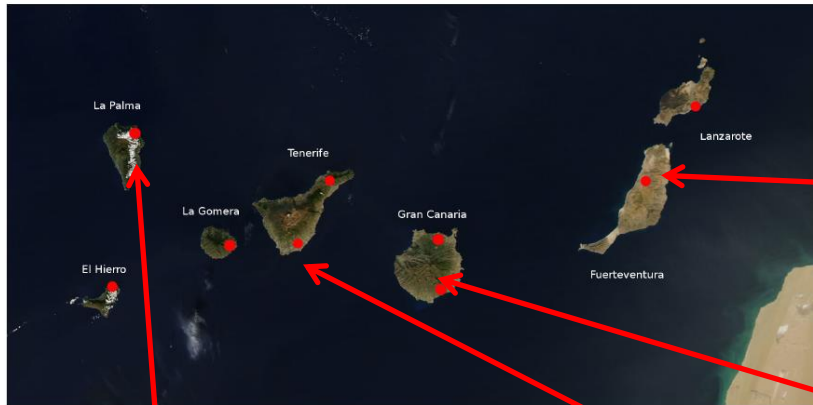
**Not all PM<sub>10</sub> is dust:** Local sources  
**Dust filter:** Moving 40th percentile of 30 days, 15 days before and 15 days after  
(Escudero et al. 2007).



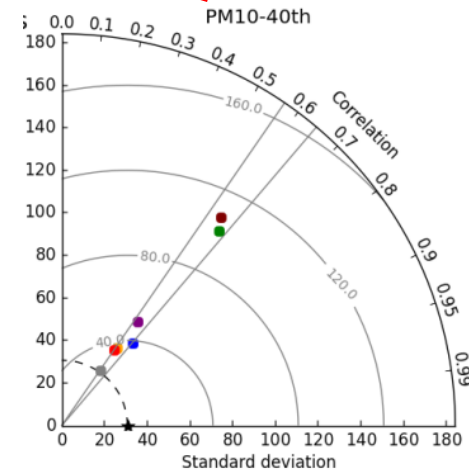
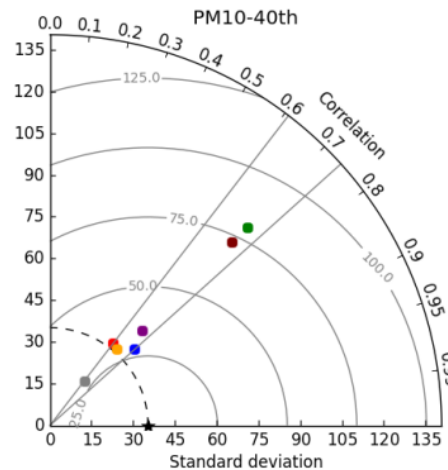
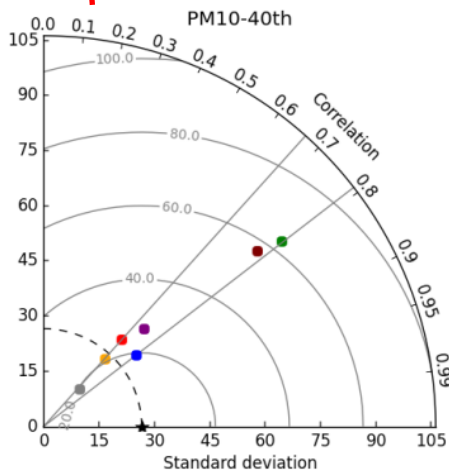
# SDS-WAS NAMEE: Model evaluation



## AQ network: Canary Islands 2013-2014



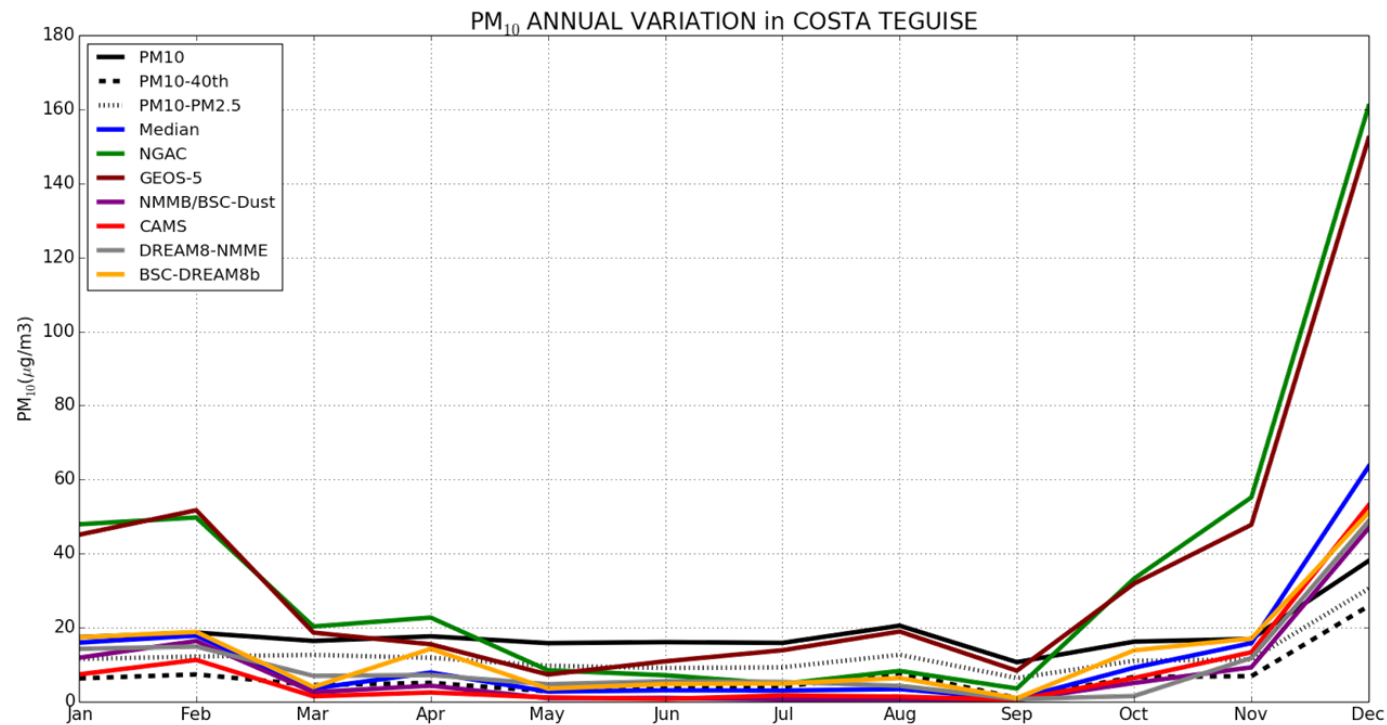
- ★ Reference
- CAMS
- Median
- NGAC
- NMMB/BSC-Dust
- BSC-DREAM8b
- GEOS-5
- DREAM8-NMME



# SDS-WAS NAMEE: Model evaluation



## AQ network: Canary Islands 2013-2014

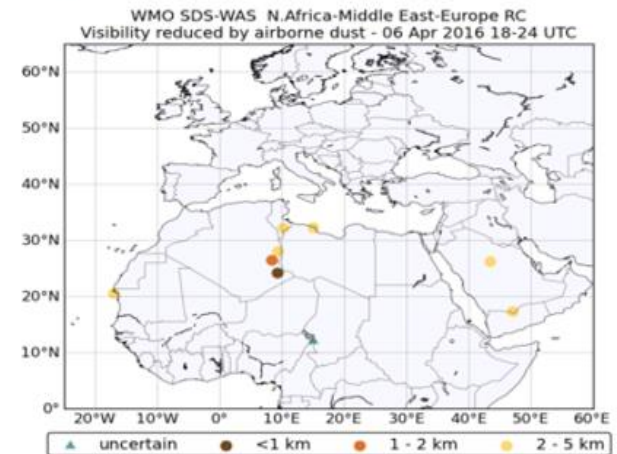
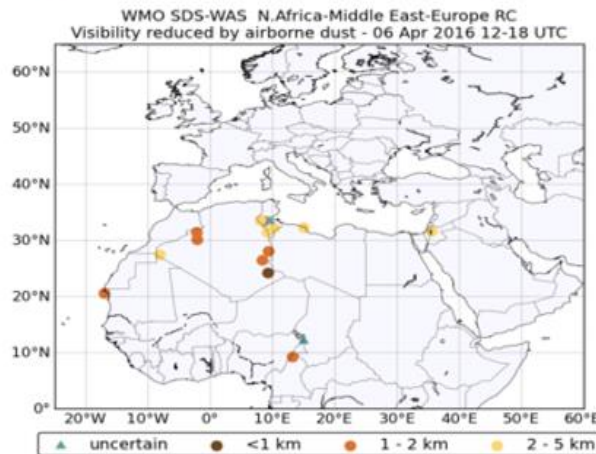
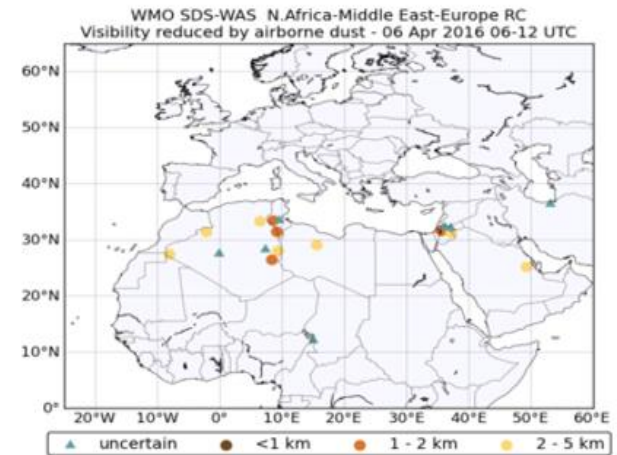
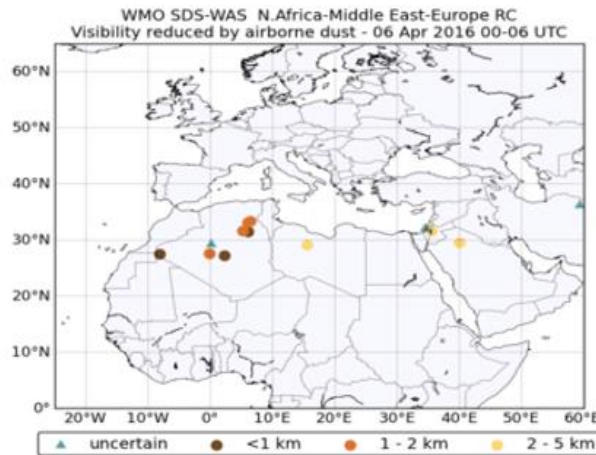
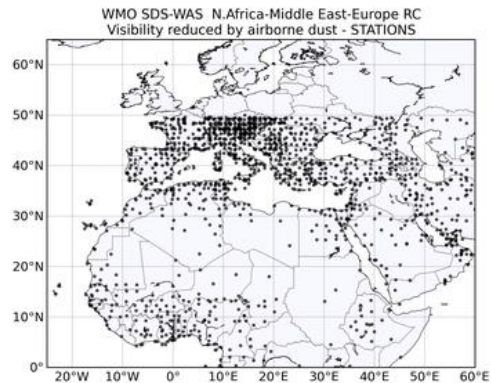




# SDS-WAS NAMEE: Model evaluation



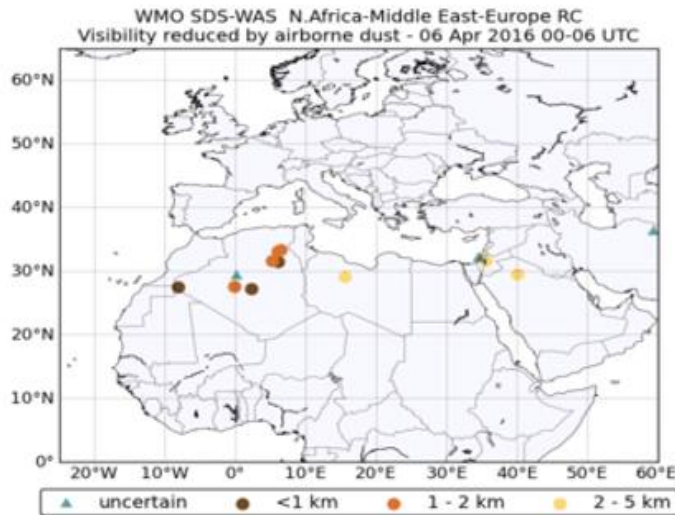
## NRT visibility evaluation: 6<sup>th</sup> April 2016 0-12UTC



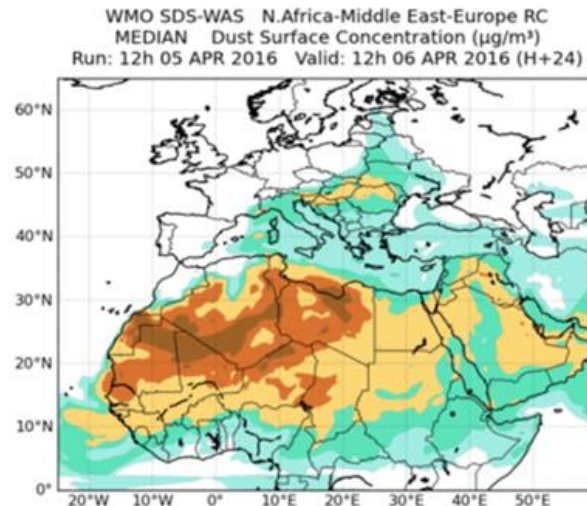
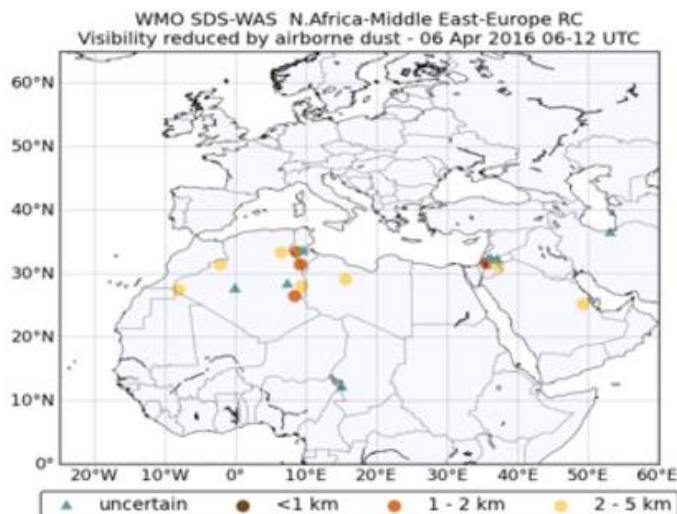
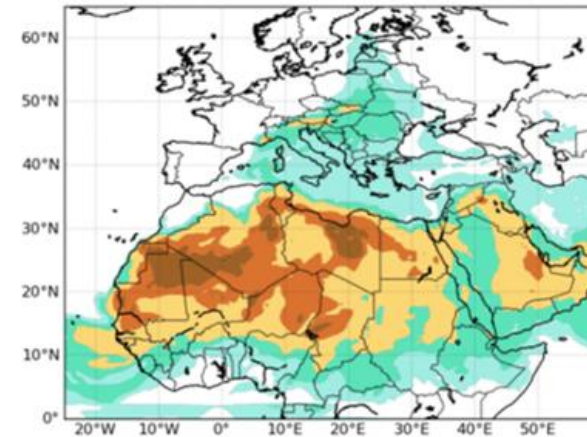
# SDS-WAS NAMEE: Model evaluation



## NRT visibility evaluation: 6<sup>th</sup> April 2016 0-12UTC



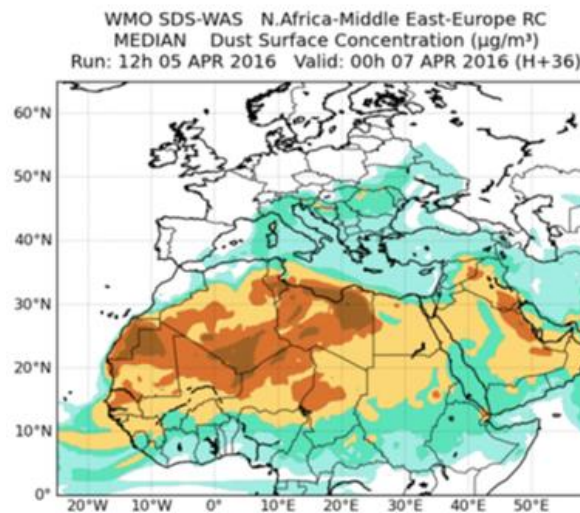
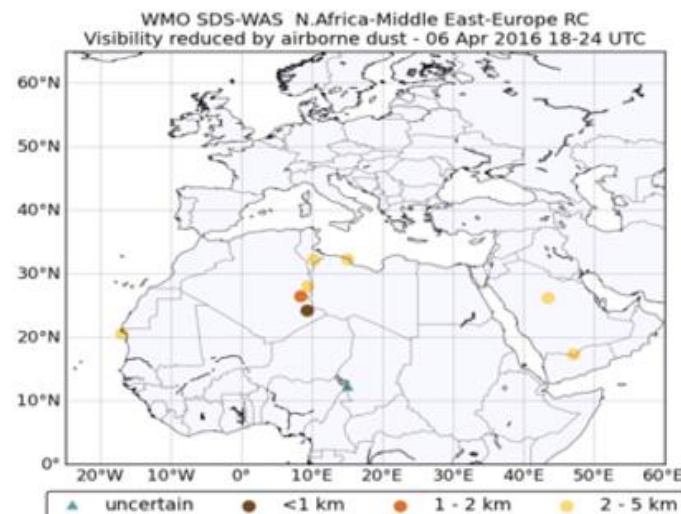
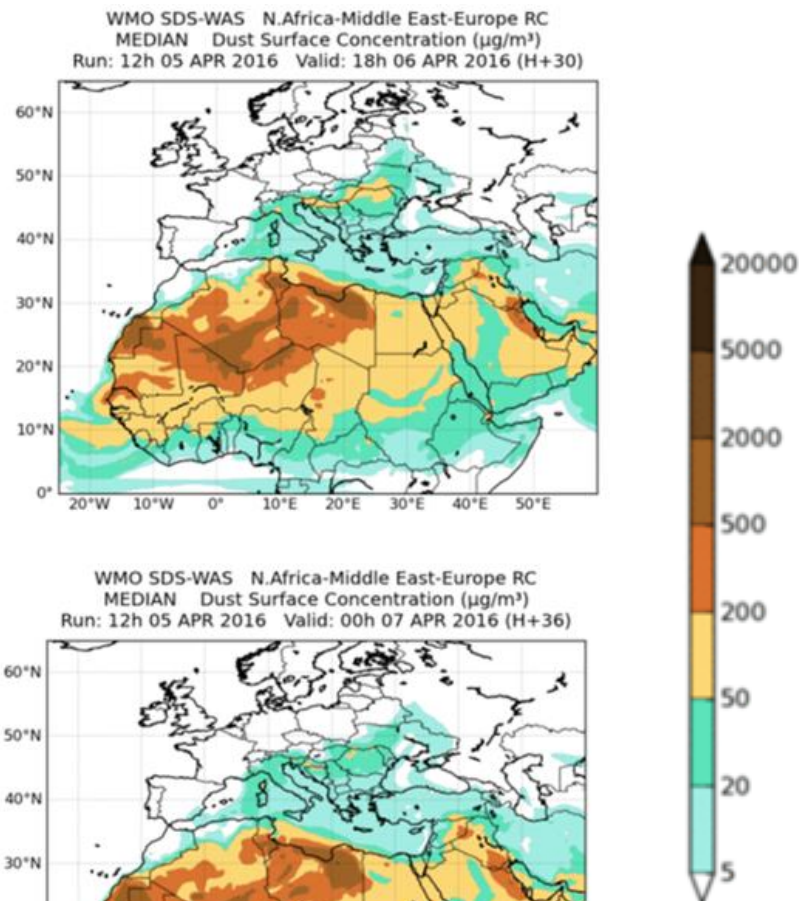
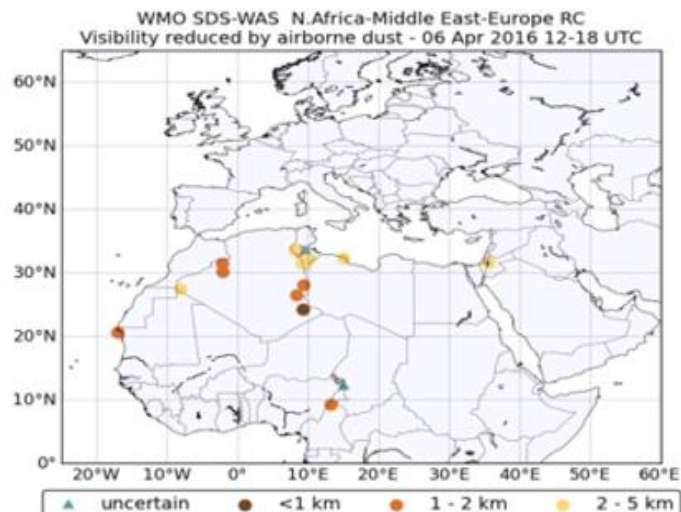
WMO SDS-WAS N.Africa-Middle East-Europe RC  
MEDIAN Dust Surface Concentration ( $\mu\text{g}/\text{m}^3$ )  
Run: 12h 05 APR 2016 Valid: 06h 06 APR 2016 (H+18)





# SDS-WAS NAMEE: Model evaluation

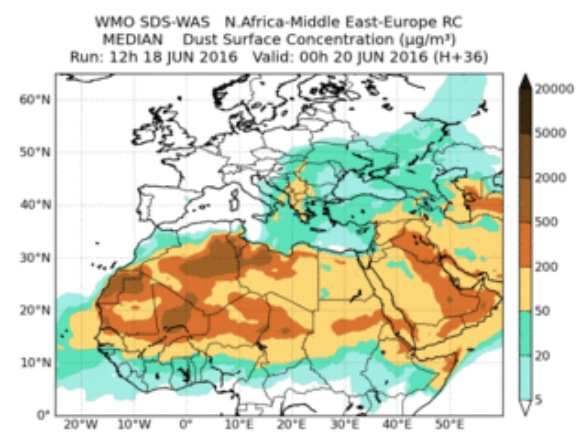
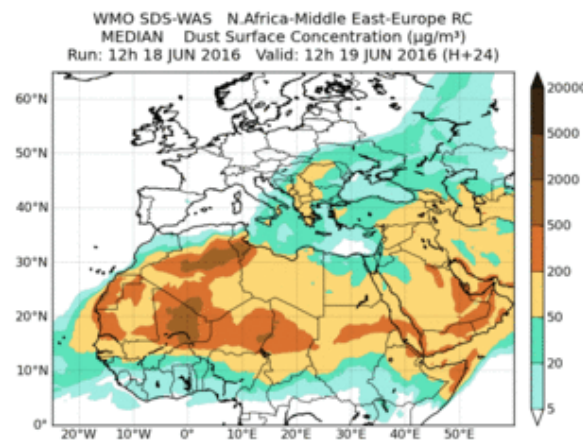
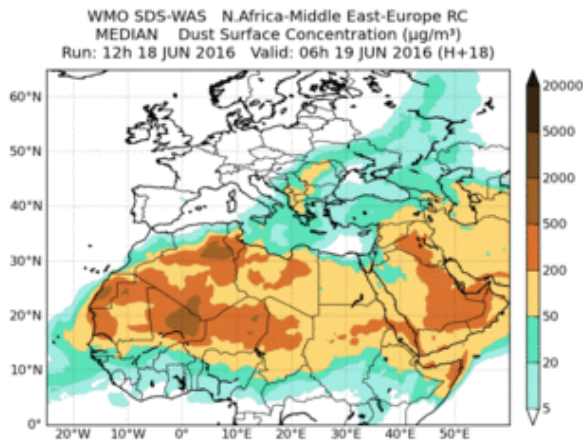
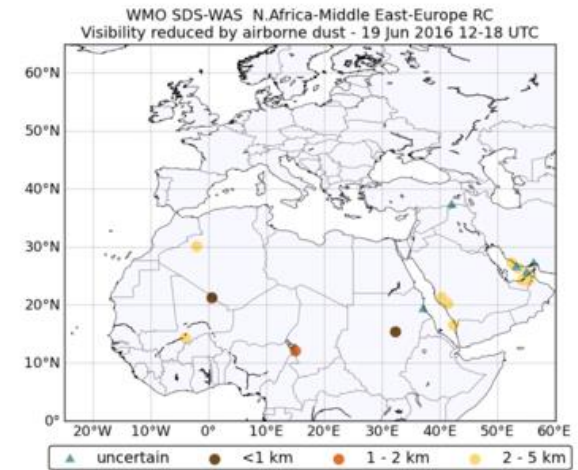
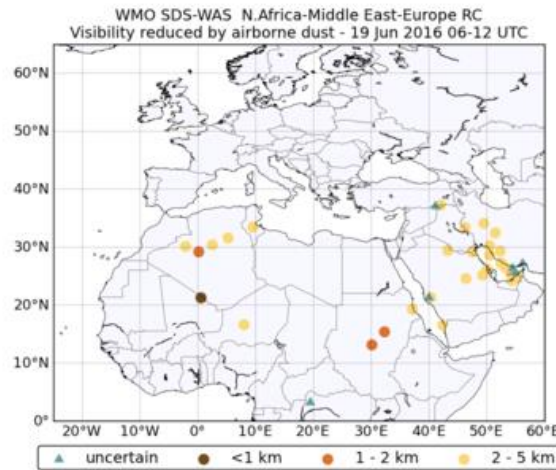
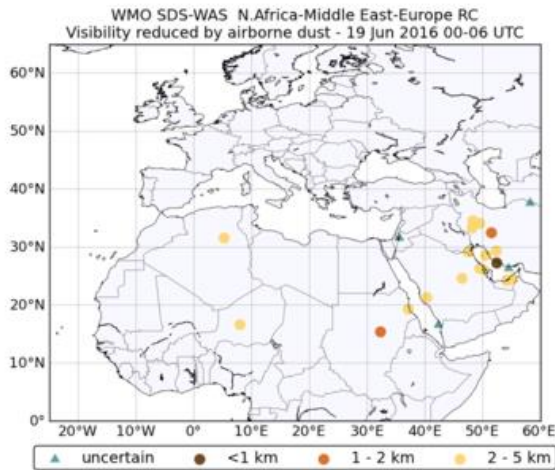
## NRT visibility evaluation: 6<sup>th</sup> April 2016 0-12UTC



# SDS-WAS NAMEE: Model evaluation



## NRT visibility evaluation: 19<sup>th</sup> june 2016





# SDS-WAS NAMEE: Model evaluation



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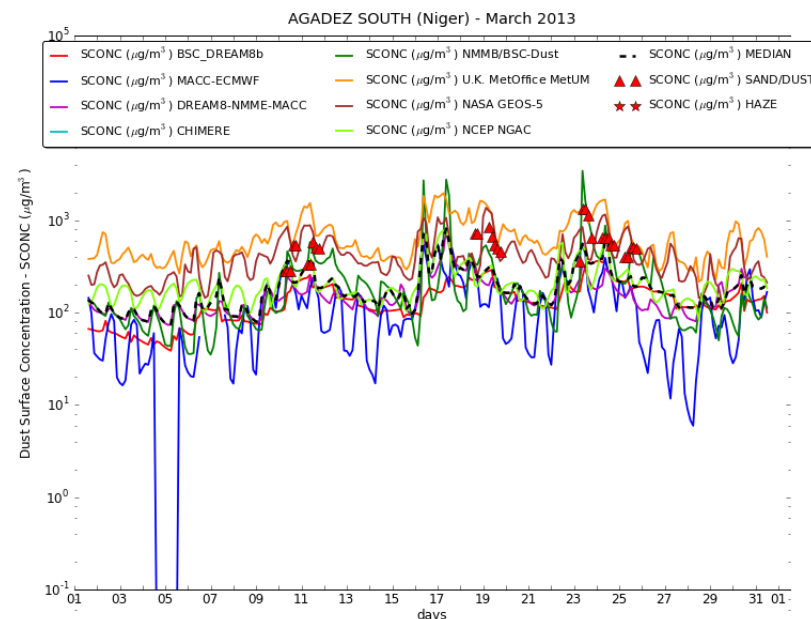
NRT visibility evaluation: 19<sup>th</sup> june 2016



AGADEZ SOUTH, Niger

$PM_{10} = 1339.84 V^{0.67}$   
Ben Mohamed et al. (1992)

$PM_{10} = 1772.24 V^{1.1}$   
Camino et al. (2014, Aeolian Res.)



# SDS-WAS NAMEE: Model evaluation



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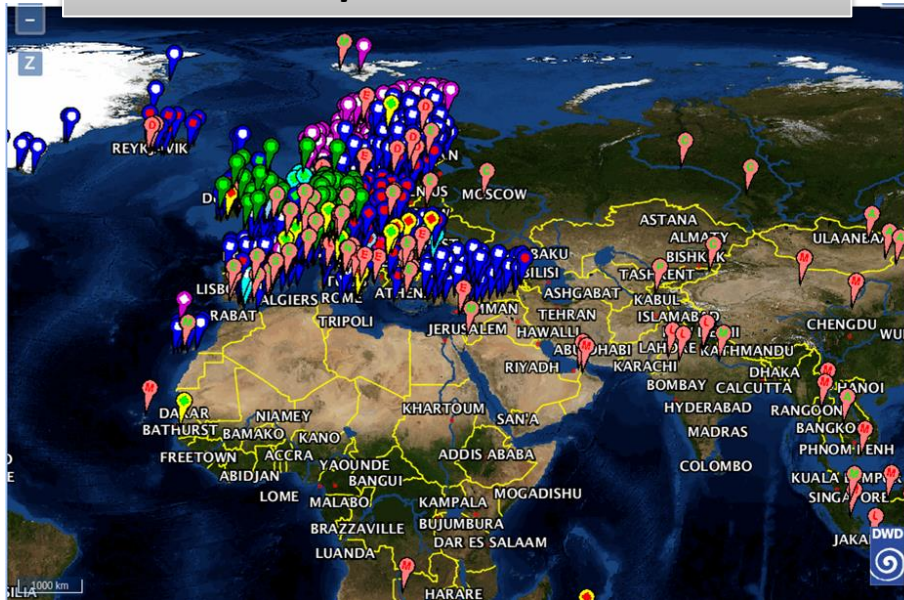
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## Ceilometer

Santa Cruz de Tenerife, Granada and Montsec (Spain)

- + High density of stations
- Qualitative products



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ugr

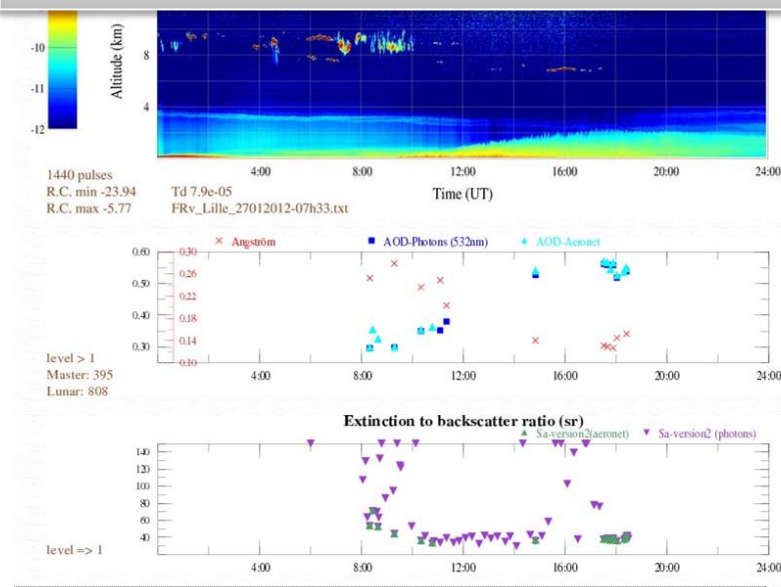
idæa



## Lidar

M'Bour (Senegal)

- Low number of stations
- + Quantitative products



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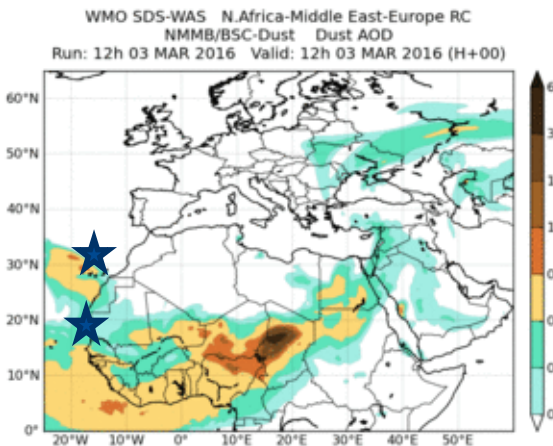
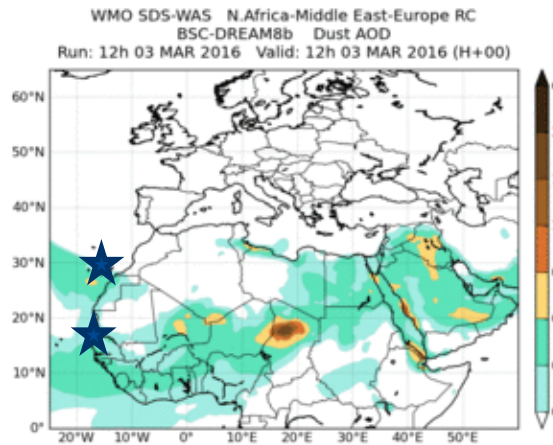
# SDS-WAS NAMEE: Model evaluation



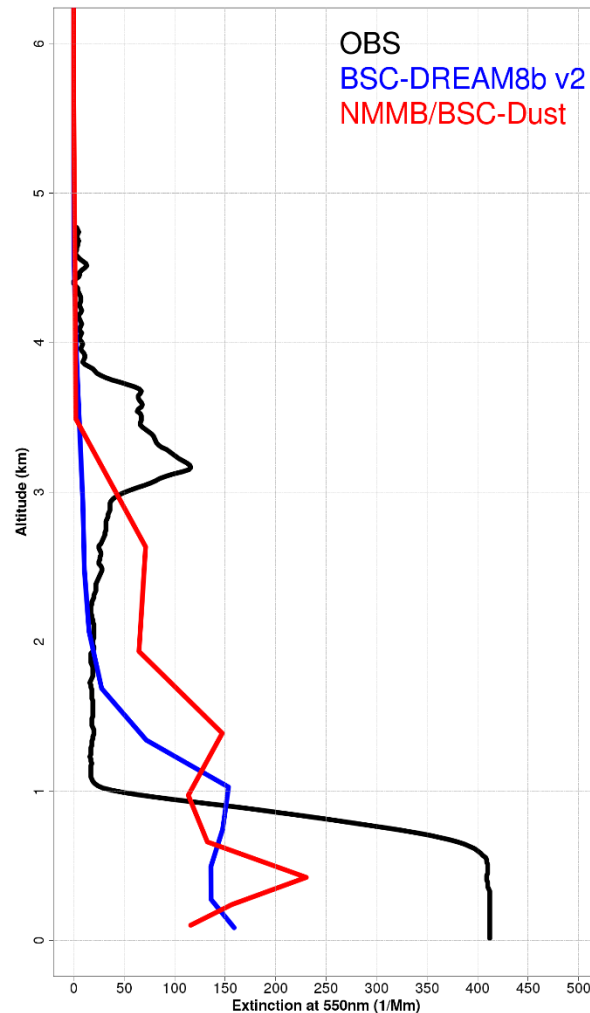
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Centro Nacional de Supercomputación

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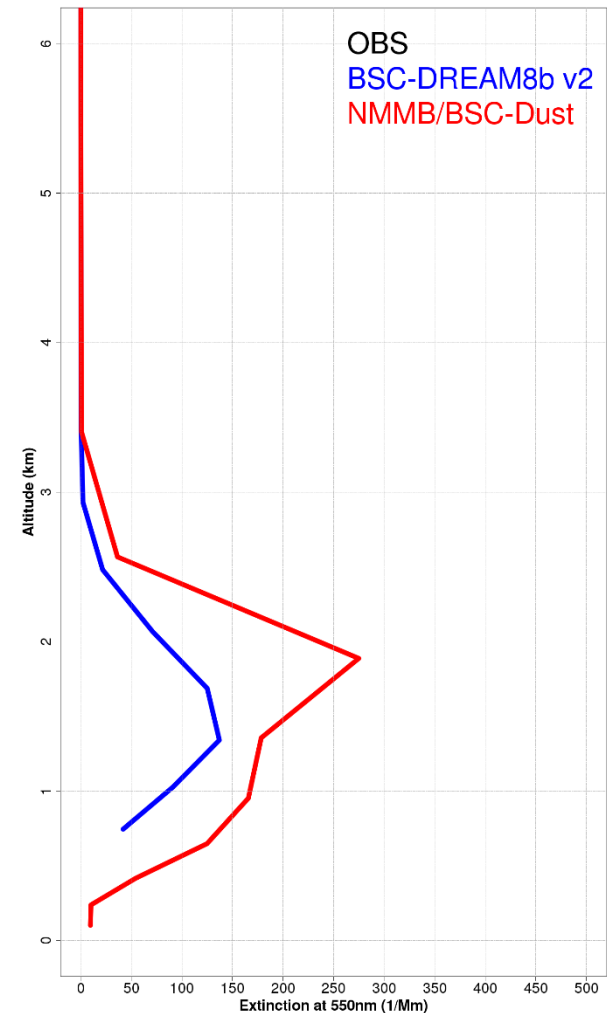
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MBour at 2016-03-03 at 12UTC



Tenerife at 2016-03-03 at 12UTC





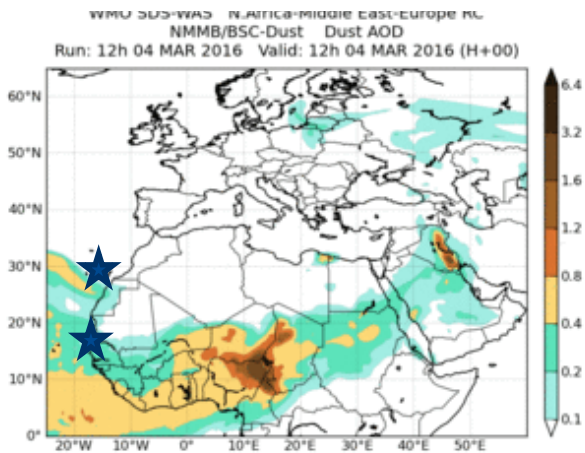
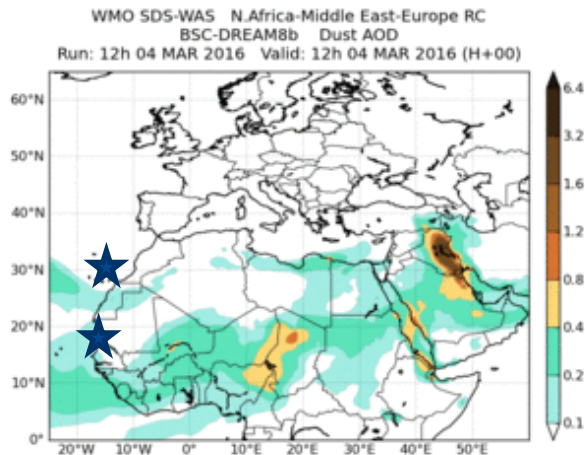
# SDS-WAS NAMEE: Model evaluation



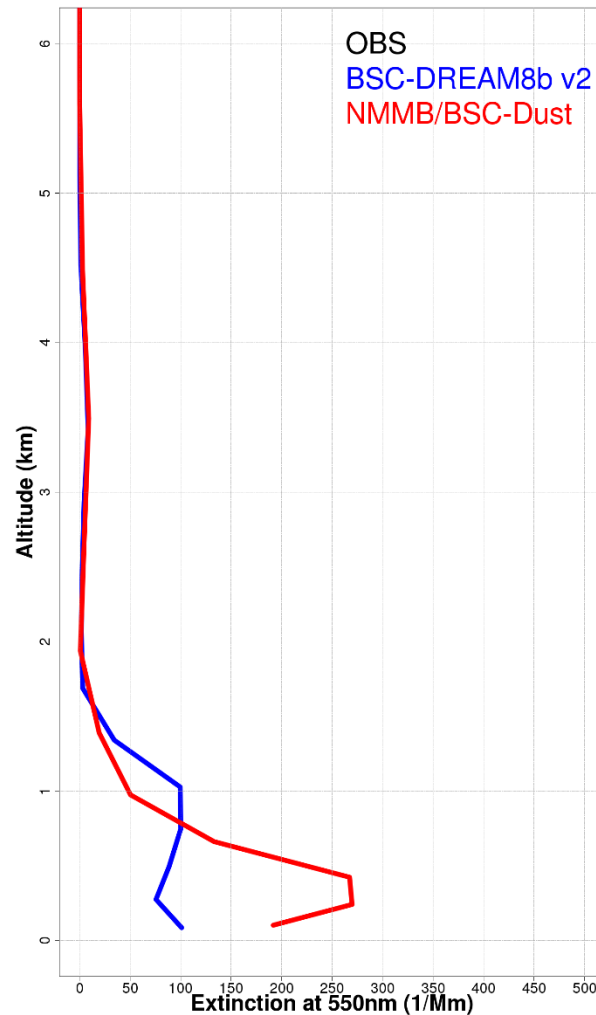
Barcelona  
Supercomputing  
Center  
Centro Nacional de Supercomputación

EXCELENCIA  
SEVERO  
OCHOA

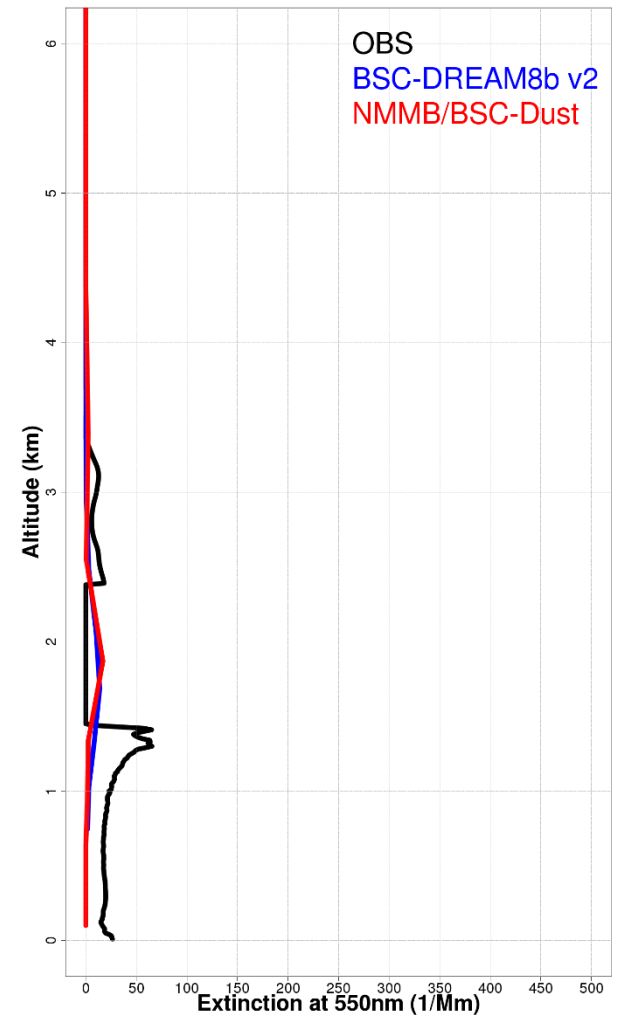
Aemet  
Agencia Estatal de Meteorología



MBour at 2016-03-04 at 12UTC



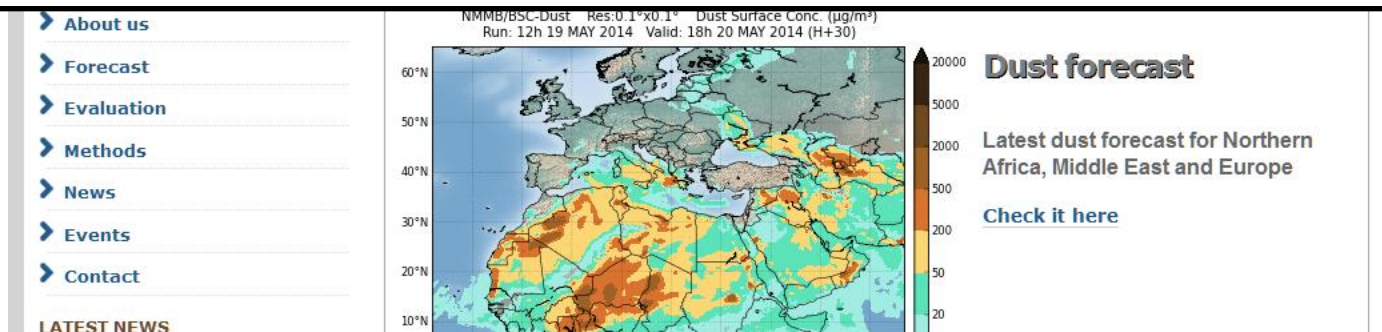
Tenerife at 2016-03-04 at 12UTC







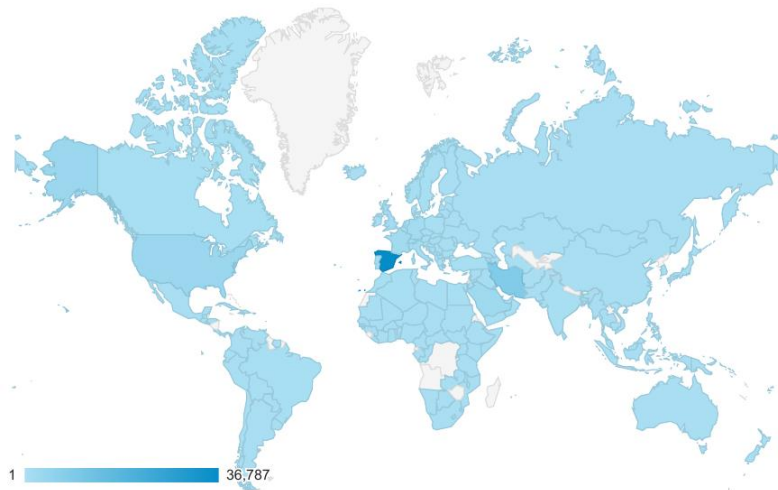
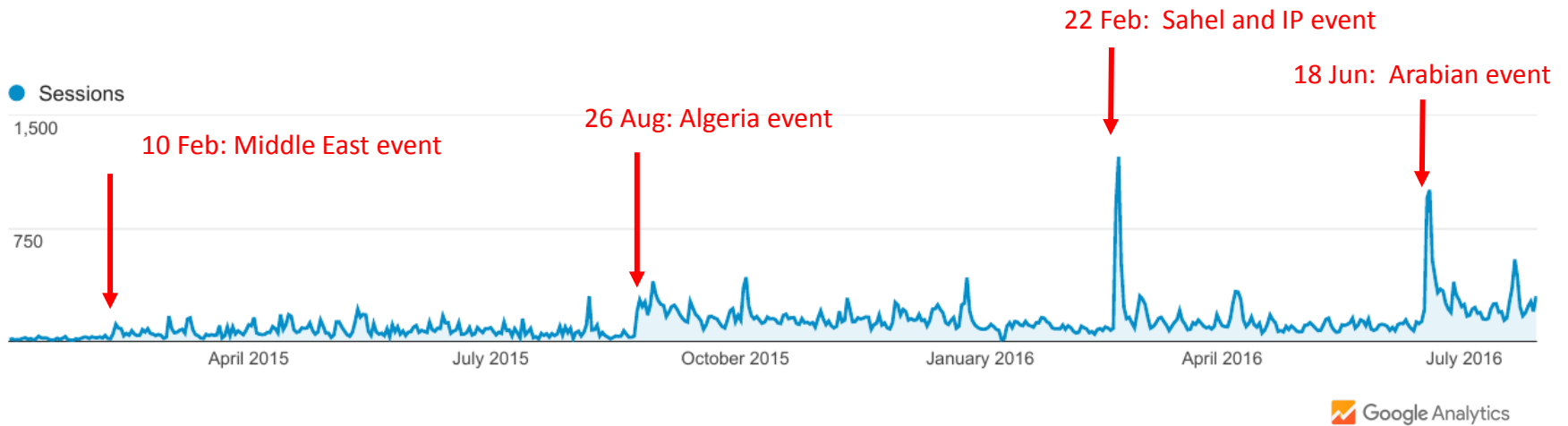
***In 2014, the First Specialized Center for Mineral Dust  
Prediction of WMO is created  
NMMB/BSC-Dust selected to provide operational forecasts  
for NAMEE region***



<http://dust.aemet.es/>

 [@Dust\\_Barcelona](https://twitter.com/Dust_Barcelona)

## Website visits: 1 January 2015 – 28 July 2016



# BDFC: Dust Forecasts products



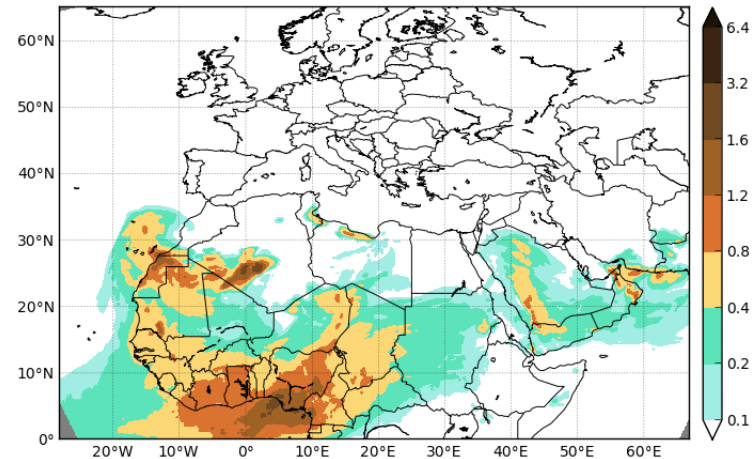
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Supercomputing  
Center**  
Centro Nacional de Supercomputación

EXCELENCIA  
SEVERO  
OCHOA

**Aemet**  
Agencia Estatal de Meteorología

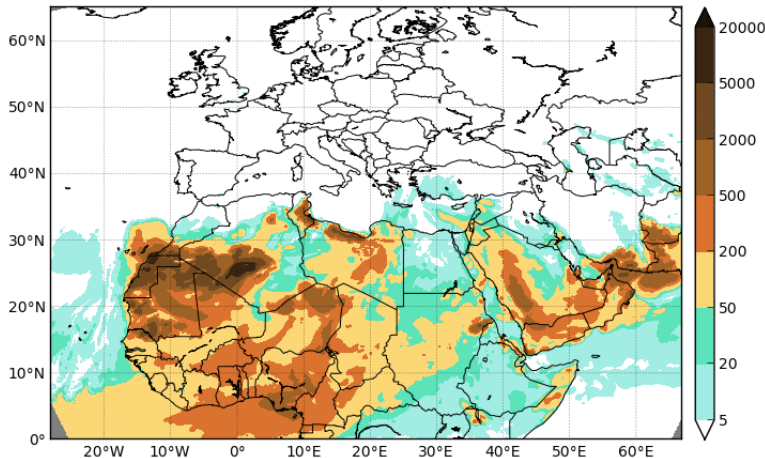


Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 07 MAR 2015 Valid: 12h 07 MAR 2015 (H+00)

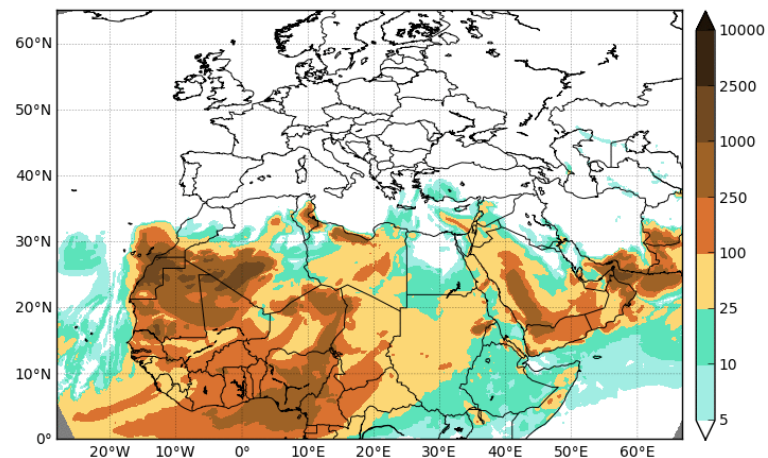


***Dust Optical Depth at 550nm***  
***Dust Dry Deposition***  
***Dust Load***  
***Dust Surface Concentration***  
***Dust Surface Extinction at 550nm***  
***Dust Wet Deposition***

Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Conc. ( $\mu\text{g}/\text{m}^3$ )  
Run: 12h 07 MAR 2015 Valid: 12h 07 MAR 2015 (H+00)



Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Ext. ( $\text{Mm}^{-1}$ )  
Run: 12h 07 MAR 2015 Valid: 12h 07 MAR 2015 (H+00)



<http://dust.aemet.es/>  
 [@Dust\\_Barcelona](#)

# BDFC: Dust event Canary Islands Feb 2015



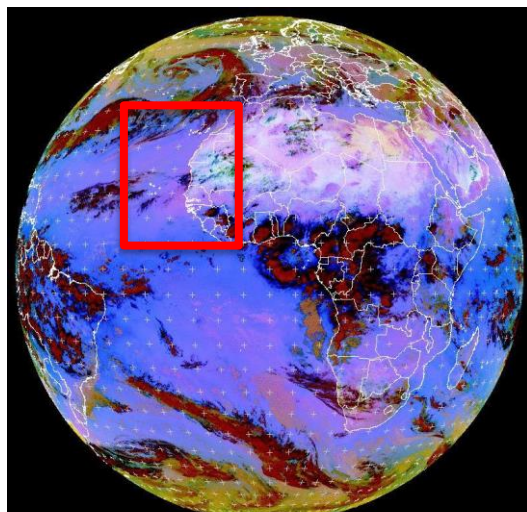
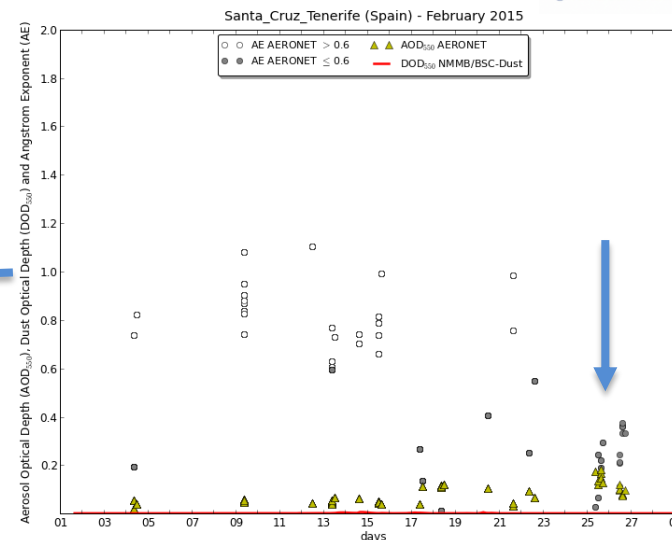
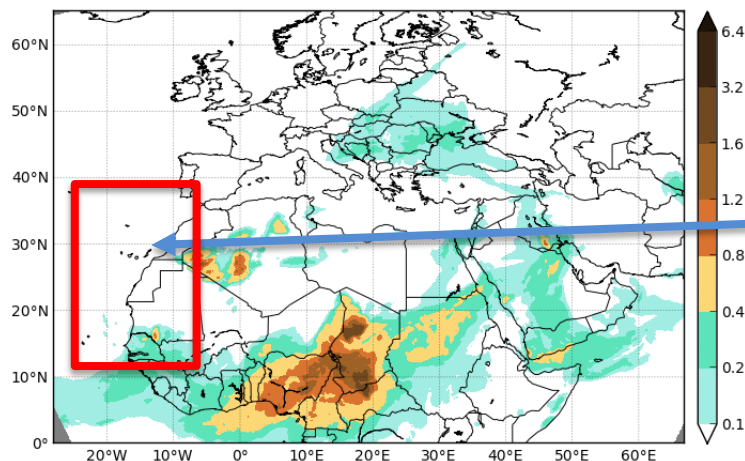
**Barcelona Supercomputing Center**  
Centro Nacional de Supercomputación

EXCELENCIA  
SEVERO  
OCHOA

**Aemet**  
Agencia Estatal de Meteorología

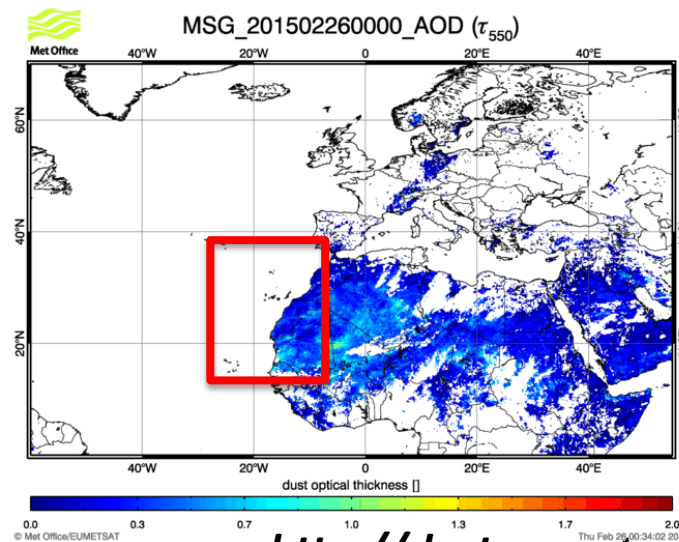


Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 25 FEB 2015 Valid: 12h 25 FEB 2015 (H+00)



RET18 RGB-Dust 2015-04-23 21:00 UTC

EUMETSAT



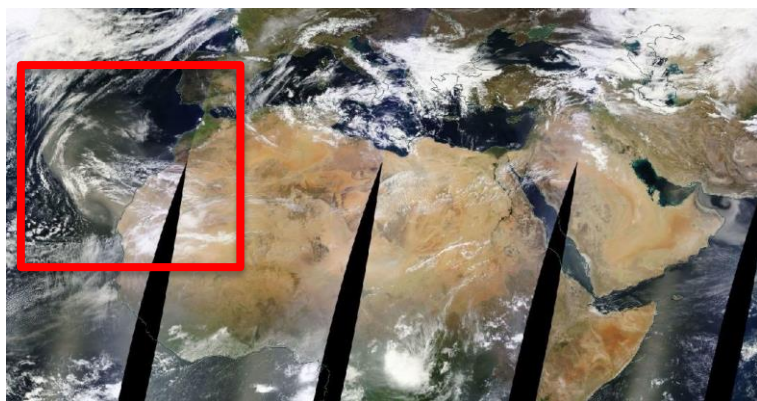
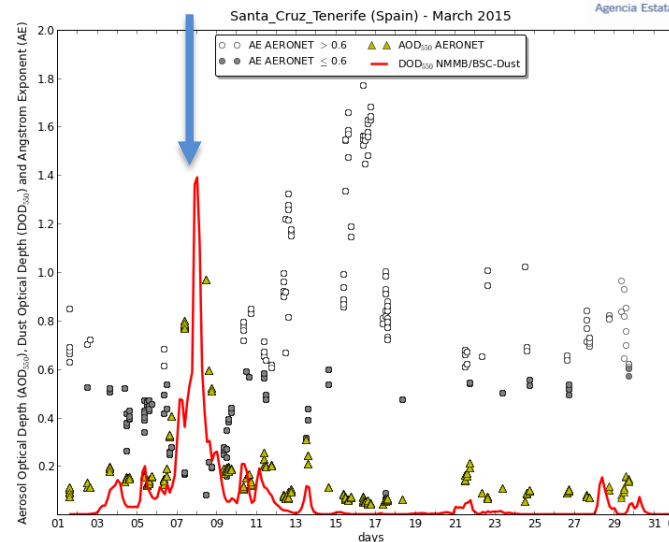
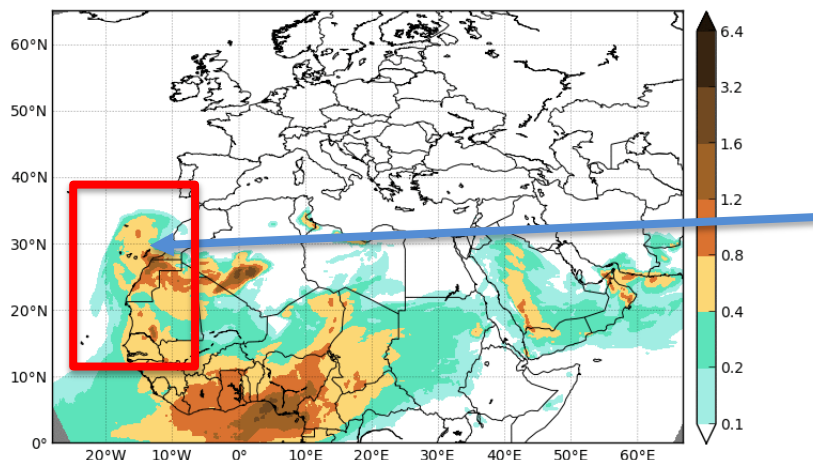
© Met Office/EUMETSAT

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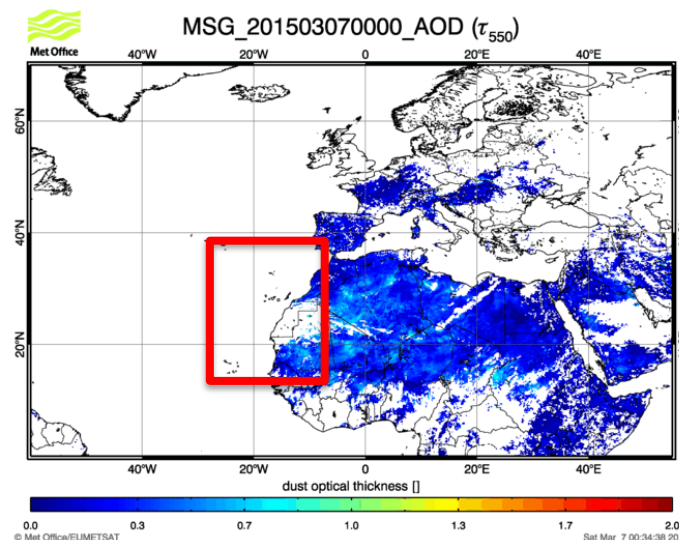


# BDFC: Dust event Canary Islands Mar 2015

Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 07 MAR 2015 Valid: 12h 07 MAR 2015 (H+00)



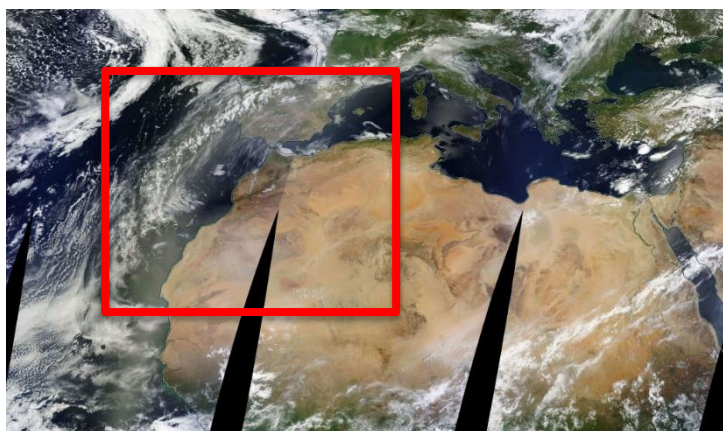
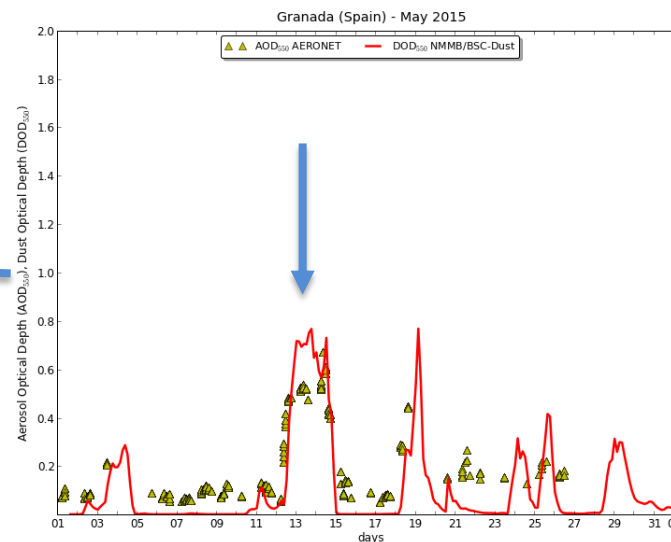
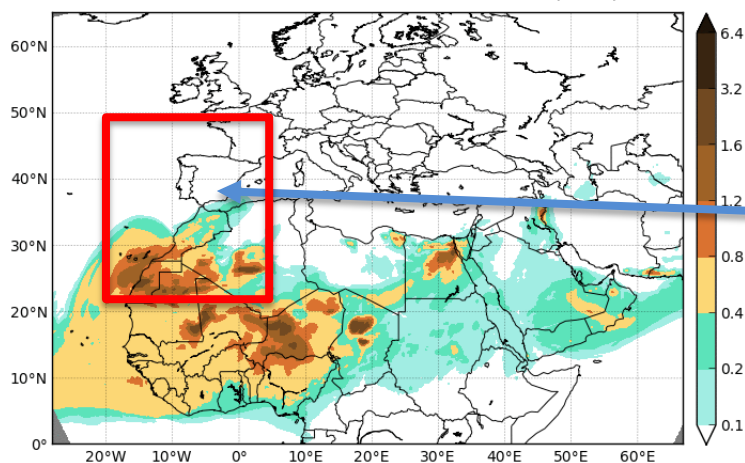
MODIS composite 8<sup>th</sup> March 2015  
from EOSDIS World Viewer



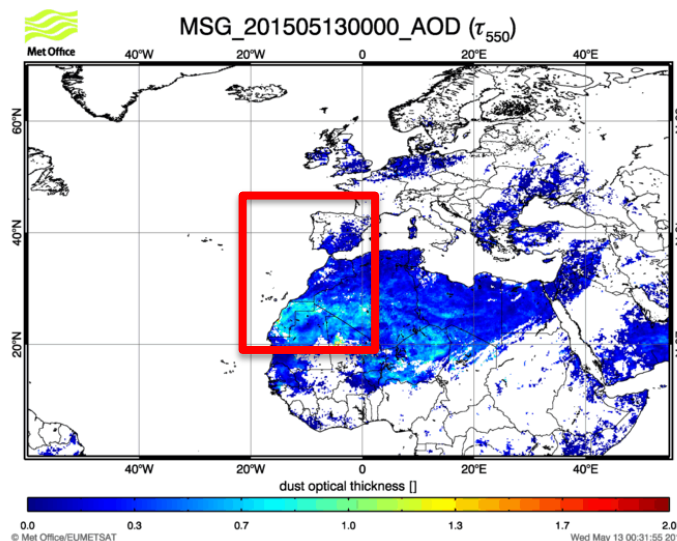
<http://dust.aemet.es/>  
@Dust\_Barcelona

# BDFC: Dust event Europe May 2015

Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 11 MAY 2015 Valid: 12h 11 MAY 2015 (H+00)

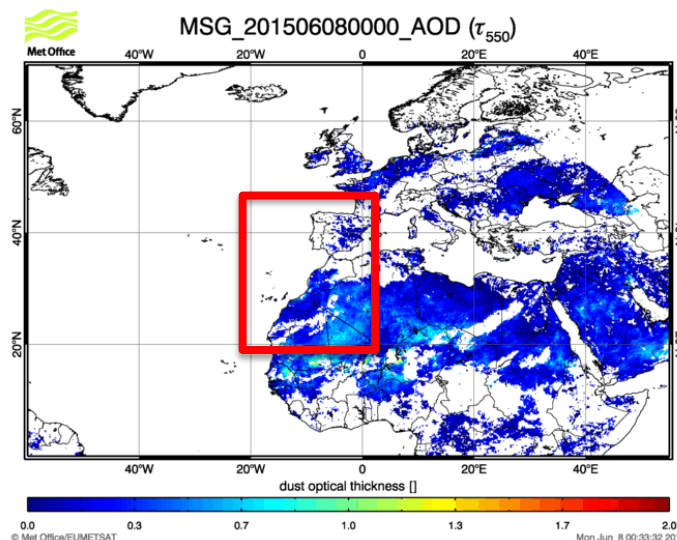
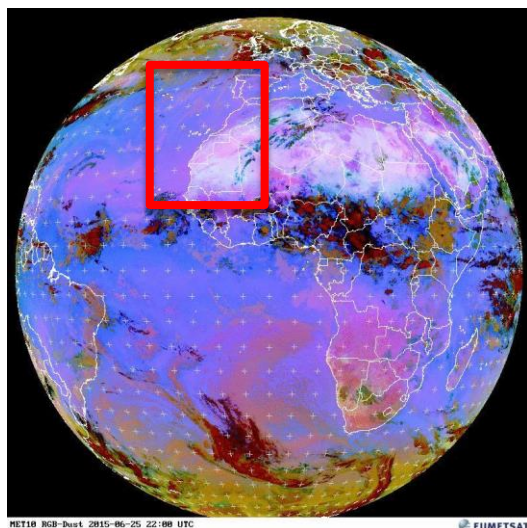
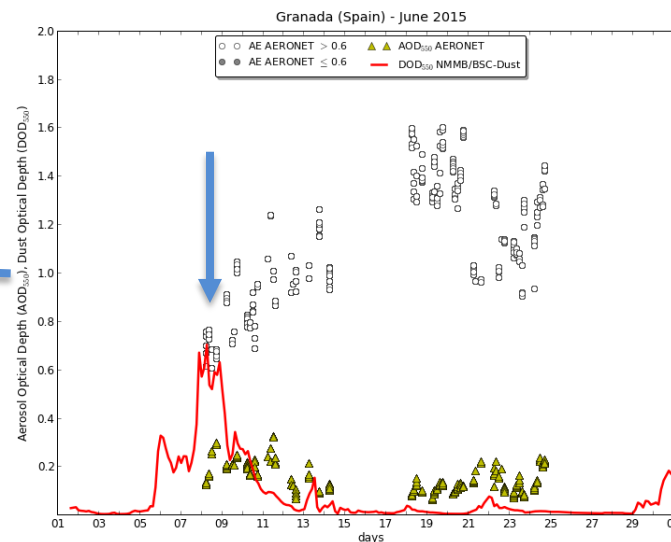
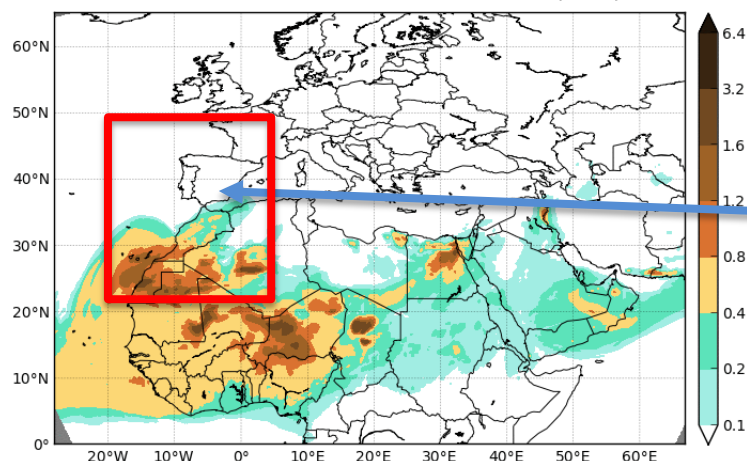


MODIS composite 13<sup>th</sup> May  
from EOSDIS World Viewer



# BDFC: Dust event Europe June 2015

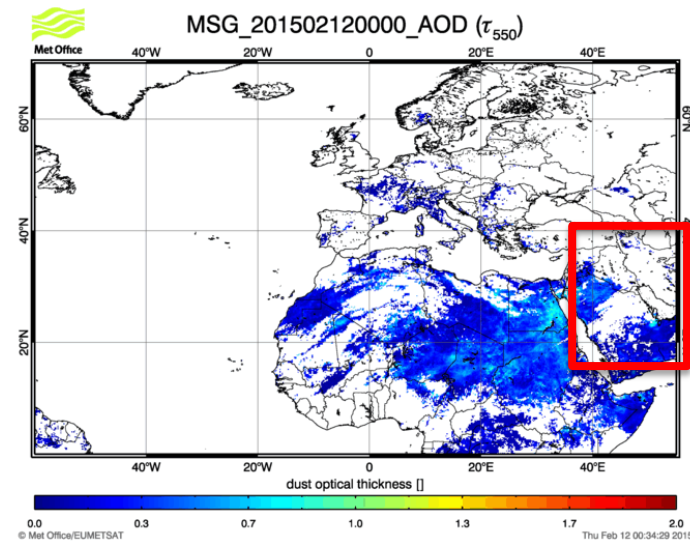
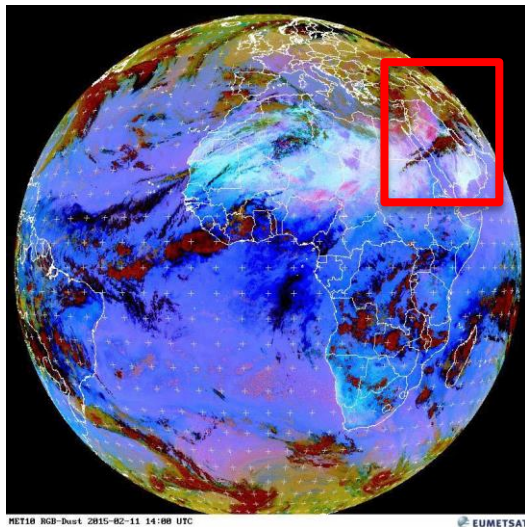
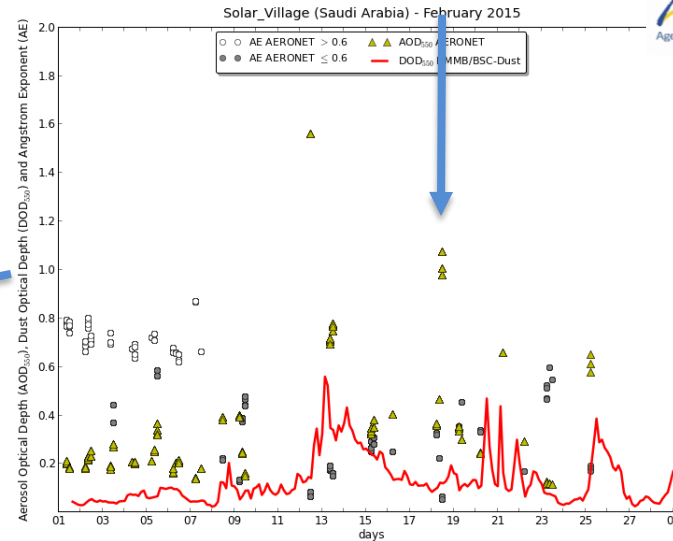
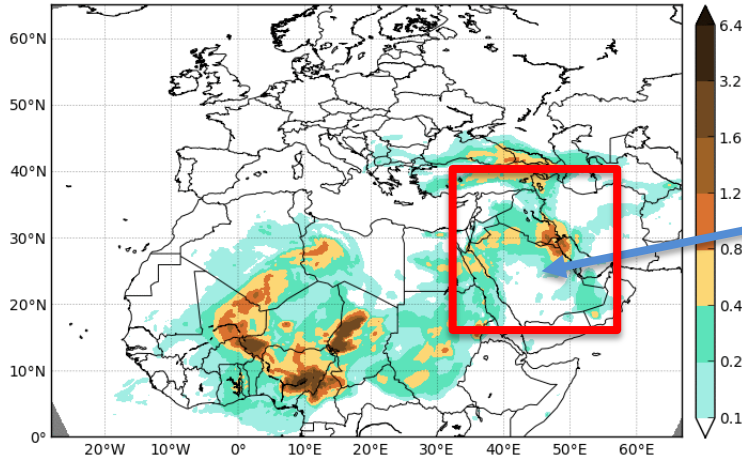
Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 11 MAY 2015 Valid: 12h 11 MAY 2015 (H+00)





# BDFC: Dust event Middle East Feb 2015

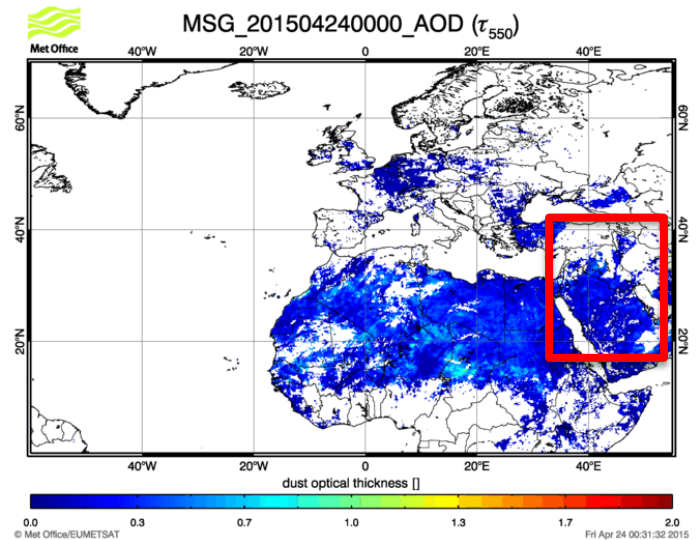
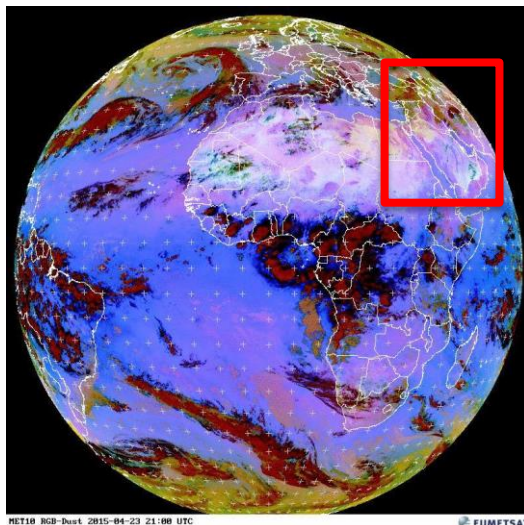
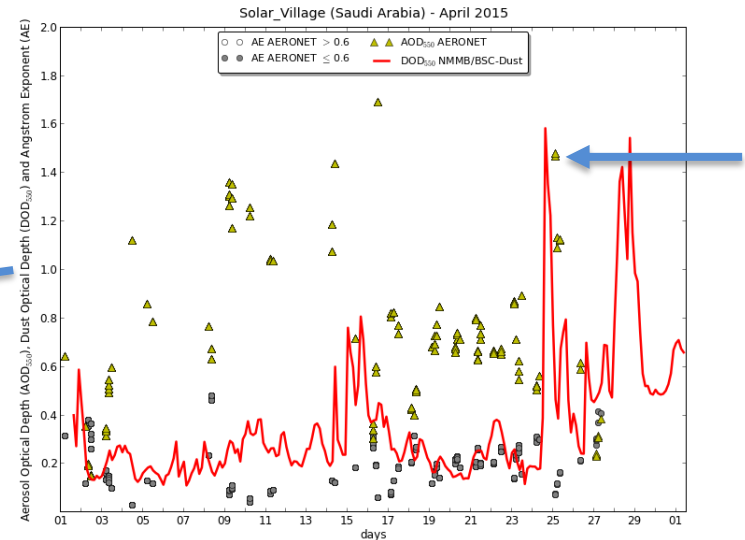
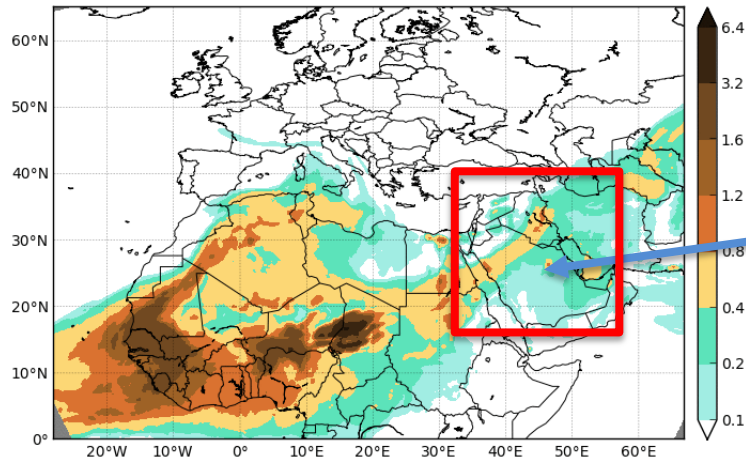
Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 12 FEB 2015 Valid: 12h 12 FEB 2015 (H+00)





# BDFC: Dust event Middle East Apr 2015

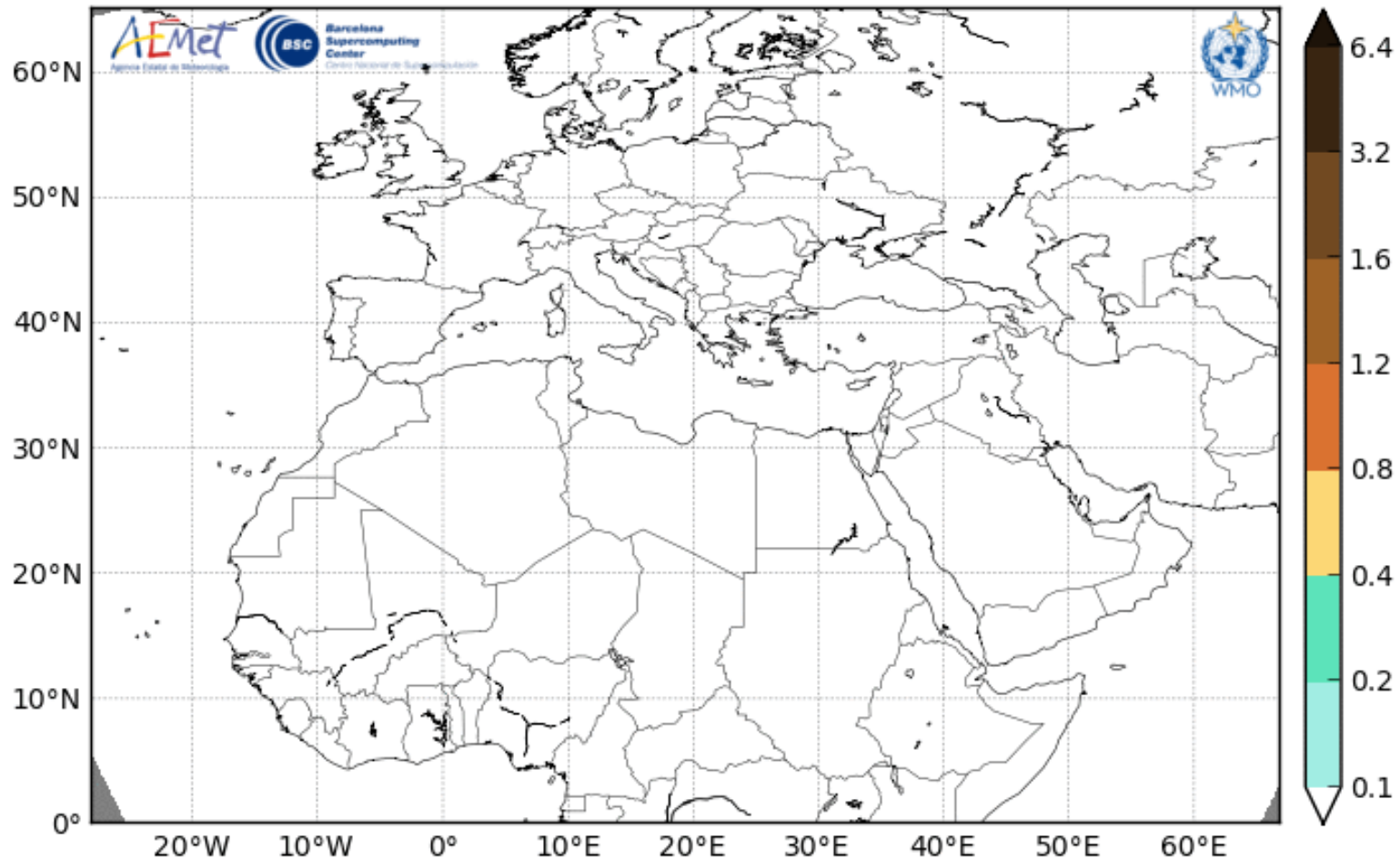
Barcelona Dust Forecast Center  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 23 APR 2015 Valid: 12h 23 APR 2015 (H+00)



# BDFC: Dust event EU October 2017



Barcelona Dust Forecast Center - <http://dust.aemet.es/>  
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD  
Run: 12h 14 OCT 2017 Valid: 12h 14 OCT 2017 (H+00)



Ongoing **NMMB/BSC-Dust** model developments to improve the quality of daily dust forecast includes:

- Data assimilation of satellite aerosol products for mineral dust analysis
- Exploration of the advantages of the high-resolution simulations (> 4km spatial horizontal resolution) → Dust sources, haboobs and complex terrains

Ongoing activities of the **WMO Dust Centers** includes:

- **Model evaluation** including data from satellites, and lidar, Sun-photometer and in-situ networks, both for gaseous and aerosol species, covering multiple time-scales.
- Increased education and awareness to promote the information and forecasts that are publically and freely available
- Establishment of appropriate communication channels for the dissemination of interpreted dust forecasts at a frequency that enables preparedness (i.e. through weather news networks, text message alerts)





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## Gracias

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